AN EMPIRICAL ANALYSIS OF THE LONG-RUN COMOVEMENT, DYNAMIC RETURNS LINKAGES AND VOLATILITY TRANSMISSION BETWEEN THE WORLD MAJOR AND THE SOUTH AFRICAN STOCK MARKETS

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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 any other University, Technikon or College for degree purpose.

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ABSTRACT

The international linkages of stock markets have important implications for cost of capital and portfolio diversification. Recent trends in globalization, financial liberalization and financial innovation raises questions with regard to whether African stock markets are being integrated into world equity markets. This study examines the extent to which the South African (SA) equity market is integrated into the world equity markets using daily data for the period 1995-2007. The study is divided into three main parts, each looking at the different ways in which integration can be considered.

The first investigates whether there is long run comovement between the SA and the major global equity markets. Both bivariate and multivariate Johansen (1988) and Johansen and Juselius (1990) cointegration approaches were utilised. Vector Error Correction Models (VECMs) are then estimated for portfolios which show evidence of cointegration. The second part analyses returns linkages using the Vector Autoregressive (VAR), block exogeneity, impulse response and variance decomposition. The third part examines the behaviour of volatility and volatility linkages among the stock markets. Firstly volatility is analysed using the GARCH, EGARCH and GJR GARCH. Simultaneously, the hypothesis that investors receive a premium for investing in more risky stock markets is explored using the GARCH-in mean. The long term trend of volatility is also examined. Volatility linkages are then analysed using the VAR, block exogeneity, impulse response and variance decomposition.

The first part established that no bivariate cointegration exists between the SA and any of the stock markets being studied, implying that pairwise portfolio diversification is potentially worthwhile for SA portfolio managers. However, multivariate cointegration exists for some portfolios, with the US, UK, Germany and SA showing evidence of error correction for some of these portfolios. Findings on return linkages is that there are significant returns linkages among the markets, with the US and SA being the most exogenous and most endogenous respectively. Findings regarding volatility are that the volatility in all the markets is inherently asymmetric and that except for the US there is no risk premium in any of the markets. The long term trend of volatility in all the stock markets was found to be relatively stable. The final finding was that significant volatility linkages exist among the markets, with the US being the most exogenous and SA and China showing evidence of bidirectional linkages. Overall, except for volatility linkages, the integration of SA into the global equity markets is still quite low. Thus, both SA and international investors can capitalise on this portfolio diversification potential. On the other hand, policy makers should capitalise on this and make policies that will attract the much needed foreign investors.

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CHAPTER ONE:
INTRODUCTION

1.1 CONTEXT OF RESEARCH

Globalization intertwined with technological progress, financial innovation and financial liberalization has drastically changed and is continuously changing the international financial landscape. Both accessibility and speed of diffusion of information have increased and information cost has decreased. This has led to increased international capital mobility and greater opportunity for portfolio diversification to reduce risk. It is however worth noting that globalisation has not only brought benefit but also widespread challenges. The financial system has become more complex from a policy-making point of view. Mergers and acquisitions between international banks have increased, thus increasing concentration in the financial system. Novel financial products and new capital structures have reduced the transparency of some participants (particularly banks) in the financial system and this raises questions concerning accounting practices and corporate governance (Rybiński, 2006:7). Finally, local financial markets and economies have become more vulnerable to volatility in international financial markets and economies through 'contagion effects' (Khalid and Rajaguru, 2005:8).

These developments in financial markets have led to a growing interest in studying the linkages and volatility transmissions in financial markets. Early studies on international linkages of financial markets occurred in the early 1970s and these were motivated by the need to determine the possibility of gains from international diversification (e.g. Levy and Sarnet, 1970; Grubel and Fadner, 1971; Lessard, 1973 and Solnik, 1974). Whilst the common finding of these early researches was that international financial markets were less harmonised, recent findings reveal increased comovement and interdependence of financial markets (see for instance Taylor and Tanks, 1989 and Kasa, 1992).

Studies on emerging markets have also increased especially since the 1990s emerging markets financial crises. Possibly due to the damaging nature of the crises, these studies have been centred on the financial impact of asymmetric volatility transmission during times of crisis and tranquillity. As a result a new debate has developed around whether financial markets are related in an 'interdependent' or a 'contagion' nature. Different results have been found in this respect, and some views in the literature attribute this to methodological differences (see for instance Corsetti *et al*., 2005).

Studies on the international integration of African stock markets have been either on how a group of the developed equity markets affect the African equity markets (see for instance Biekpe and Collins, 2003; Forbes and Rigobon, 2002; Lamba and Otchere, 2001) or on the integration and volatility transmission among the African stock markets (see Piesse and Hearn, 2002 and Biekpe and Collins, 2003). In the former studies, there is consensus that the African stock markets are generally independent of the developed stock markets. Notable exceptions are South Africa and Egypt (Lamba and Otchere, 2001:22; Biekpe and Collins, 2003:193). The latter studies generally conclude that the South African equity market is the dominant equity market in Africa, both in terms of level influence and volatility transmission (see Biekpe and Collins, 2003:191 and Hearn and Piesse, 2005:43). This is not a very surprising trend as South Africa is Africa’s oldest and largest stock market in terms of both market capitalisation and trade volumes (Beelders, 2002:624).

There are a number of reasons why understanding the international linkages of equity markets is important. These include financial regulation, stock market efficiency, portfolio diversification and effectiveness of monetary policy. For instance, financial regulators need to take cognisance of volatility transmission from foreign financial markets when formulating policies that are aimed at stabilising the financial system (Corsetti *et al.*, 2005:2). On the other hand, successful international portfolio diversification requires that comovement among stock markets is low or negative so that a poor performance in one national market would be 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 (2003b) have empirically shown that monetary policy has been shown to respond to movement in stock markets.

South African policy-makers seem to have acknowledged that the understanding of linkages and volatility transmission in financial markets is an important ingredient in formulating macro-economic policy. For instance the Governor of the South African Reserve Bank (SARB) argues that “We talked then about volatility in the financial markets and acknowledged that it was becoming a constant feature as the processes of deregulation, liberalization and globalization continued to gather momentum” (Mboweni, 2004:2). However, despite this acknowledgement, very little has been done to determine either the source, nature or the speed and magnitude at which volatility is transmitted from the world major equity markets into the SA equity market. Thus, it is important to determine which of the world equity markets most influences the SA equity market, in terms of both returns and volatility.

1.2 OBJECTIVES OF THE STUDY

The main objective of the research is to identify which among the developed and emerging stock markets - the US, the UK, the German, the Japanese, the Australian and the Chinese - has the strongest influence on the SA equity market. The ultimate goal is to suggest investment and policy advice and to assess the extent to which the SA market is integrated into the major global equity markets. The specific goals of the study are as follows:

- To examine the long-run comovement between the South African (SA) stock market and the above-mentioned stock markets with a view to analysing the extent to which SA long-term investors can benefit from international portfolio diversification.
- To examine the dynamic returns/mean linkages between the SA and the above mentioned stock markets as well as the speed, magnitude and nature of these mean linkages and whether there are any reverse influences i.e. from SA to these markets.
- To examine the nature of volatility in each of the stock market, its long-run trend and to test the risk premium hypothesis.
- To examine volatility linkages between the above-mentioned and the SA stock markets as well as the magnitude and speed of volatility transmission from these stock markets into the SA stock market.
- To suggest investment and policy advice.

1.3 MOTIVATION FOR THE STUDY

Apart from contributing to scant existing literature for SA and re-examining the linkage of the SA market in the face of the changing domestic institutional environment, this study also goes an extra mile in terms of the issues considered. Whilst the existing studies on the linkages between the SA market and the major world markets have mainly focused on returns linkages, this study considers long term comovement and returns linkages as well as volatility transmission. Unlike the previous studies, very high frequency data (daily) is employed in this study. This is because it is our considered view that stock markets reacts promptly to news and thus low frequency would fail to capture such dynamics. Furthermore, the hypothesis of risk premium in stock markets and the trend of volatility in stock markets which, to the best of our knowledge, have not yet been considered in any of the existing studies for SA equity market are explored. Another contribution is that given the nature of the issues being studied, some of the methodologies employed in this study have not been used in any of the existing relevant studies for SA.

The study focuses on the equity market and not other financial markets because together with the bond market the stock market is a useful source of finance. However, the stock market seems to be more responsive to international events than the bond market since returns in the bond market are directly influenced by conditions of domestic monetary policy. The response of world stock markets to the Asian crisis is yet another indication that the stock markets tend to react to international events. However, this does not imply that studying the linkages of other financial markets is not important.

The preliminary choice of international stock market for this study is not arbitrary, but has been motivated by various factors. The choice of the US stock market is due to the fact that it is the world's largest market. On the other hand, the UK is vital because of its historical importance to South Africa i.e. colonisation and historical trade links as well as being the fourth largest stock market in the world. A further consideration is that there has been an agreement between the JSE and the London stock exchange for dual listing of companies. Germany was chosen because it is one of the world's and European leading equity markets and the German economy is the strongest in the Euro region. As such it is often used to represent the European Union. The Japanese market has been chosen because it is the world's second largest stock market, whilst China is the world's fastest growing emerging economy. Lastly, the Australian equity market was chosen because, apart from being one of the top twelve markets in the world, like the SA equity market it is largely resource-based. A further consideration is that these three developed equity markets are the most recurring in relevant finance empirical literature.

Since the equity market is vital for the various reasons mentioned above (i.e. regulatory, investment, monetary policy) knowing the stock markets that mostly influence SA's will help in coming up with pro-active action in the face of expected events in the developed stock markets. Given that the SA equity market greatly influences other African equity markets, the results from this research could be very helpful to policy makers and investors in other African countries.

Based on the outcomes of the research, policy that could help reduce any negative influences from the foreign stock markets will be recommended. Investment advice will also be suggested for fund companies that seek to invest in foreign stock markets. Since the SA equity market influences most African equity markets, the implications of this for other African countries will also be articulated.

1.4 METHODS OF THE STUDY[2]

This section briefly describes the methodology followed in order to achieve the objectives and sub-objectives laid out above. Firstly, we will carry out an in-depth review of the relevant theoretical

[2] A full discussion of the econometrics methodology followed in this paper is given in Chapter 4.

and empirical literature. For our empirical analysis we will utilise daily stock market indices for the period 1995:06 – 2007:02. This period has been chosen because it is our considered view that the post-independence pro-market reforms that SA undertook could have had an implication on its integration in to the world economies. Prior to the application of formal econometric methodology, several descriptive statistical tests and simple correlation will be done. Some of the statistical tests include the mean, variance, standard deviation, skeweness, 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. In order to tackle the first sub-objective (i.e. long run comovement of the stock markets) both bivariate and multivariate forms of the Johansen (1988) and Johansen and Juselius (1990) cointegration approach will be utilised. To address the second objective we will utilise the Vector Autoregressive Model, together with the impulse response and variance decomposition analyses. To address the third sub-objective, we first use three different Generalised Autoregressive Conditional Heteroscedasticity (GARCH) models to analyse volatility in each stock market. These are the GARCH (1, 1), exponential GARCH (EGARCH) and GRJ GARCH (or TARCH). We then generate volatility (conditional variance) series using the most appropriate model of the three. Thereafter, these volatility series will be analysed using a Vector Autoregressive (VAR) methodology together with impulse response and variance decomposition functions to examine the speed and magnitude of the volatility transmission.

1.5 ORGANISATION OF THE STUDY

This study is organised as follows: The next chapter reviews both theoretical and empirical literature regarding long run comovement, mean linkages and volatility transmission among stock markets. This chapter is divided into three main sections, notably the importance of understanding linkages in financial markets, the nature of linkages in stock markets and finally the empirical literature. Chapter 3 gives a brief overview and comparison of the equity markets being studied. Chapter 4 describes the econometric methodology used in this study, including cointegration analysis, Vector Autoregressive (VAR) and Generalized Autoregressive Conditional Heteroscedasticity (GARCH). The results of the study are presented and discussed in Chapter 5. The presentation and discussion of the results are done chronologically as per each of the methodologies discussed in the preceding chapter. Chapter 6 provides the conclusions, policy and investment recommendations as well as suggesting further research areas.

CHAPTER TWO:
THEORETICAL ISSUES AND LITERATURE SURVEY

2.0 INRODUCTION

This chapter considers both theoretical and empirical literature on the various issues regarding long run comovement, returns linkages and volatility transmission among equity markets. The chapter is divided into different sub-sections each focusing on the different blocks that form the entire body of the literature. The first section explores the importance of understanding the linkages among equity markets. This is followed by a section reviewing the nature of the possible returns and volatility linkages that might exist between stock markets. The next section reviews the empirical literature regarding long run comovement, returns linkages and volatility transmission. The empirical literature has been divided into three sub-parts each focusing on developed, emerging and African stock markets respectively. Finally, the last section concludes by reconciling the three main sections forming the chapter as well as linking to the context and objective set out in Chapter 1.

2.1 WHY IS UNDERSTANDING LINKAGES AMONG FINANCIAL MARKETS IMPORTANT?

The need for understanding the linkages among financial markets in general, and stock markets in particular, should by no means be underestimated. About four reasons have been suggested as to why the understanding of linkages and volatility transmission in financial markets is important. These include portfolio diversification, regulatory policy, monetary policy, and efficient market hypothesis. These are discussed below.

2.1.1 PORTFOLIO DIVERSIFICATION

The goal of portfolio diversification is to maximise return at given risk or minimise risk at given level of return. This is enabled by putting wealth in different securities or assets. Portfolio diversification can take different forms. Firstly, it can involve putting wealth in different securities in the same market. For instance, the entire wealth can be invested in the equity market, but in different sectors or companies. Secondly, the portfolio can comprise securities from different markets, such as the equity market, money market and bond market. A third form of portfolio diversification would be to invest in the same market but in different countries, for example, a portfolio made up of equities from SA, UK and UK stock markets. Lastly, a portfolio can be comprised of securities from different financial markets located in different countries.

Modern portfolio theory suggests two main conditions for beneficial portfolio diversification. Firstly, in order to minimise the risk of a portfolio, the assets included in a portfolio should be weakly correlated (Glezakos *et al.*, 2007:25). Secondly, the securities should be negatively correlated. This will ensure that if one asset gets negative returns, the other will get positive returns and the net effect will be that losses from one asset will be covered by the gains from other assets.

Analysis of international linkages of equity markets is particularly concerned with the third form of portfolio diversification. Darrat and Benkato (2003:1090) and Morana and Beltratti (2006:2) suggest that for international equity markets to be weakly correlated, the assets should not be driven by similar macro-economic fundamentals. In turn weakly correlated assets will provide an opportunity for international diversification as already mentioned. It is widely predicted that globalisation and financial market integration would erode much of the gains from international diversification by making increasing comovement and enhancing spillovers among international stock markets.

2.1.2 REGULATORY POLICY

It is generally agreed that the financial system is one of the most regulated sectors of the economy. One of the reasons for this is that it is closely interconnected with the macroeconomy. It is for this reason that some authors have argued that its malfunction is tantamount to the failure of the 'economic engine' (Faure, 2006a:124). Thus, one can see that regulation of the financial system is indispensable as the consequences of its failure are far-reaching. Some of the reasons for financial regulation according to Faure (2006a:124) are to protect the financial system from systemic malfunctioning, the existence of market imperfections, the moral hazard problem, economies of scale, consumer confidence and consumer demand for regulation. The reasons can generally be grouped into three: to promote financial stability through ensuring systematic stability and institutional safety and soundness, to achieve fair and healthy competition in the financial system, and to protect consumers.

Stock markets are an important part of the financial system, thus they are not an exception to strict regulatory policy. Most stock markets are self-regulated although the legislation is normally set by the government through an independent body. For instance, in South Africa the stock market is self-regulated through the Johannesburg Securities Exchange although the Financial Services Board is the ultimate regulator. In order to appropriately enact or amend this legislation and other regulatory policies, it is important for the financial regulators to understand the nature and the behaviour of the stock market. The linkages and volatility transmission between financial markets from an intra-national and international perspective are vital factors that determine the behaviour of a stock market. Thus, to set appropriate regulatory policy, it is necessary to understand how shocks in financial markets are propagated and how investors transmit funds from one market to another as they adjust their portfolios.

2.1.3 MONETARY POLICY

As Faure (2006b:113) puts it “Monetary policy embodies the formulation and execution of policies by the central bank (in the form of open market operations to render repo rate effective) aimed at guiding bank lending rates to levels where credit demand (and its counterpart: money) growth are at a level consistent with aggregate supply elasticity, all of which are premeditated on the attainment of low inflation (usually targeted) and high and sustainable economic output.” Irrespective of which tools are used in implementing monetary policy, a monetary policy stance does not directly affect the targeted ultimate goals. However, it passes through various stages which are referred to as the transmission mechanism of monetary policy.

The link between the stock market and monetary policy stems from the importance in the transmission mechanism of monetary policy. Mishkin (2001:1) and Rigobon and Sack (2003b:639-640) document three channels through which interest rate can be linked to the prices of equity. These are the effect of the stock market on investment, the firm balance-sheet effects and household liquidity and wealth effect. The first channel emanates from Tobin’s (1969) ***q*** theory, which argues here is that a decrease in interest rates leads to an increase in stock prices. This then increases ***q*** and ultimately fixed and portfolio investments. The firm’s balance sheet and liquidity channel emanates from the fact that high stock prices will increase a firm’s net worth, thus lessening the incentive to undertake risky projects. As a result the willingness of banks to give loans will be increased. 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 depends upon the expected financial distress, and more liquid assets will be held if households have a high expectation of financial distress. Thus 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.

However, monetary policy can also respond to stock prices. For instance, monetary authorities have recently realised that stock price bubbles and bursts have an impact on some macroeconomic variables such as inflation, investment and aggregate demand (IMF, 2003:62-63). Modigliani (1971) argues that asset prices may affect inflation through the consumption life cycle. According to this argument, households’ life-time income resources are comprised of stocks and other financial assets. In this regard if stock prices increase, household wealth will increase and this could increase current consumption expenditure, which through aggregate demand will lead to inflation. Central banks will respond to this by increasing interest rates. Nevertheless, of much concern is the volatility of stock prices rather than the prices themselves. If stock markets are very volatile, then inflation and interest rates will also be volatile. However, this can only be the case when stock prices are inflationary as monetary authorities will only respond to inflationary stock price changes (Mishkin, 2001:16). From this discussion, it is clear that 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.

2.1.4 STOCK MARKET EFFICIENCY

According to Fama (1970) the efficient market hypothesis (EMH) implies that equity markets are informationally efficient. This hypothesis is in three forms: the weak form, the 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. In this respect, technical analysis cannot be utilised to attain profit in equity market (Faure, 2006c:162). On the other hand, the semi-strong form efficiency argues that information currently available to the public is already reflected in stock prices and therefore it can not be used to make profits. Thus fundamental analysis has no value in such stock markets. 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 stock prices have already incorporated it (Keane, 1983:5).

From the above definitions of the different forms of the EMH, it is clear that the EMH is concerned about the speed at which past, currently available and future information is diffused in the securities prices. As an investor or a policy maker, it is pertinent to understand and appreciate this speed of transmission in financial markets. For an investor, such an understanding can help in formulating profitable and risk-minimising diversification strategies. On the other hand, the appreciation of the speed of transmission will help a policy maker to know how shocks are propagated and transmitted in financial markets and the implications of such transmission to financial stability. In turn relevant policies could be formulated. Equity markets do not only respond to information from the local environment, but also to the international macroeconomic environment. Thus, investors and government need to understand transmission from both local and international environments.

2.2.0 NATURE OF LINKAGES AND VOLATILITY TRANSMISSION AMONG STOCK MARKETS

Understanding the nature of linkages is important both from a policy making and investment point of view. For instance, if international/regional financial markets are linked in such a manner that cost of capital for the whole region will be reduced, then this could positively enhance economic growth. To reap the benefit of economic growth, regional policies that further strengthen such integration can thus be advocated. On the other hand if international/regional financial markets are linked in such a manner that the domestic economy becomes vulnerable during times of financial turmoil, then policies that help stem such negative effects can be formulated. From an investment point of view the nature of linkages and volatility transmission has implications for securities pricing and transmission of risk across equity markets. These are interdependence or contagion and symmetry or asymmetry[3].

2.2.1 INTERDEPENDENCE VERSUS CONTAGION

The financial crises in the late 1990s led to a growing interest in empirical studies on whether financial markets are related in a ‘contagious’ or ‘interdependent’ manner. Interdependence of equity markets refers to the normal comovement or linkages of stock markets. Stated differently, interdependence can be seen as the correlation of equity markets during periods of financial stability (Daly, 2003:74). In contrast, contagion can be defined as an increase in correlation of stock markets during periods of financial turmoil (Bongiglioli and Favero, 2005:1300). As an example, if two markets are averagely linked during periods of stability and one of the markets experiences a financial shock whose ripple effects significantly increase the market co-movement, this would constitute contagion. On the other hand, if correlations of the equity markets do not significantly increase irrespective of the financial shock, then any higher level of market comovement suggests strength in real linkages in the two stock markets. Another way to look at these concepts is to establish a stock market’s correlation function during a period of stability and then test it for structural breaks during or after a macroeconomic shock in one of the markets. If the function experiences a significant structural break, then there is contagion between the stock markets (Bongiglioli and Favero, 2005:1300). For further clarification, a directional dimension can be considered in defining these two concepts. As noted by Gonzalo and Olmo (2005:4), contagion implies collapse of one market that produces a fall in the other market, whereas interdependence implies that both markets collapse due to the fact that they are influenced by similar macroeconomic fundamentals. In a nutshell, contagion implies that there is a fundamental increase

[3] It should be noted that investigating the nature of linkages among stock market requires the application of methodologies some of which are beyond the scope of this study. In this paper, we only test the symmetric-asymmetric hypothesis and not the interdependence-contagion hypothesis.

in cross-market linkages after a shock, while interdependence implies that there are no significant alterations in cross market linkages after a financial crisis (Daly, 2003:75).

Daly (2003:75) proposes three reasons for understanding whether financial markets are related in a ‘contagion’ or ‘interdependent’ nature. Firstly, an important principle of investment strategy is that most macroeconomic disturbances are country-specific, such that correlation between international financial markets is low. Under such circumstances international diversification would substantially increase expected returns and reduce portfolio risk. If financial markets are correlated in a ‘contagion’ manner, then in the case of a negative economic shock, correlation between financial markets will increase and in turn much of the gains from international diversification are blown away. The second motivation has to do with investor’s behaviour models (Daly, 2003:75). The assumption behind most risk models is that investors react differently after a large macroeconomic shock. Thus an understanding of how individual investors react to good and bad news is an important ingredient in understanding how macroeconomic shocks are transmitted across international equity markets. Lastly, the contagion of financial markets is of concern to international financial institutions and policy-makers. The transmission of negative shocks from one country’s equity market to another could negatively influence the flow of financial resources even though the macroeconomic fundamentals of the second country are very sound.

2.2.2 SYMMETRY VERSUS ASYMMETRY

The transmission of return and volatility across equity markets is sometimes subject to change. The arrival of macroeconomic news in a stock market causes investors to adjust their portfolios. News can be of two types, i.e. good and bad news. The size of the reaction of investors could differ depending on news arriving in the market. If the magnitude of reaction of investors to good news is equal to the size of their reaction to bad news, then transmission of returns and volatility across is said to be symmetrical. Asymmetric transmission is a situation whereby different news (good and bad) of the same magnitude causes different proportions of reactions from investors. Specifically, asymmetry in return and volatility transmission implies that negative news (i.e. bad news) has more impact on returns and volatility than good news of the same magnitude.

Campbell and Hentschell (1992) suggest a twofold explanation for such a scenario in equity markets. Firstly arrival of bad news leads to a tumble of the stock markets. This will result in an increase of the debt-equity ratio (measured in market value terms). Consequently, the financial risk of companies will increase causing a higher volatility of their stock returns. This is normally referred to as the leverage effect. The second explanation is that of volatility feedback. With regard to this, large pieces of good news tend to be followed by other large pieces of news (so-called volatility clustering). These pieces of news increases future expected volatility, which in turn increases the required rate of return on stocks and lowers stock prices. Thus, the initial positive effect of good news will be dampened. In a case where pieces of bad news precede each other, future volatility and required rates of return will also increase. The final impact will be the amplification of the negative impacts caused by the initial bad news.

2.3 EMPIRICAL EVIDENCE ON COINTEGRATION, RETURNS LINKAGES AND VOLATILITY TRANSMISSION AMONG EQUITY MARKETS

The trend towards globalisation and liberation of financial markets has led to growing interest in studying the benefits from international diversification. The seminal work by Grubel (1968), which expounded the gains from international portfolio diversification, stimulated further studies in the 1970s. These studies were based on different methodological frameworks such as Granger Causality and Simple Correlation (see Granger and Morgenstern 1970; Levy and Sarnet, 1970; Grubel and Fadner, 1971; Ripley, 1973; Lessard, 1974 and 1976; Solnik, 1974; Panton *et al*, 1976 and Hillard, 1979) and despite the use of divergent methodology, the overwhelming finding was that correlations among returns to national stock markets were low with national factors dominating returns generating process. However, some studies (e.g. Agmon, 1972 and 1973) found a substantial amount of correlation among US, UK, German and Japan. As the process of globalization, technologies progress, financial innovation and financial liberalization continue to gain momentum, the picture of findings started changing since the 1980s. Most of the recent studies (e.g. Eun and Shim, 1989; Isakov and Perignon, 2000; Rigobon and Sack, 2003a; Bala and Premaratne, 2004; Forbes and Chinn, 2004; Bonfiglioli and Favero, 2005, etc.) reveal increased comovement and correlation among stock markets.

Existing empirical literature can be broadly classified into three parts according to the issues that the literature seeks to address. The first part focuses on long run comovement of stock market indices using cointegration or principal component analyses. The existence of long-run relationships among stock markets implies that although they may diverge in the short-run, they will be highly correlated in the long run. This will in turn mean that long term diversification in them will be unlikely to yield significant benefits in terms of risk reduction (Allen and McDonald, 1995:35). The second part of the literature focuses on the linkages of financial markets in terms of returns – so called ‘first moment’ and the third part focuses on volatility linkages – also called ‘second moment’ linkages. Whilst most studies analysing returns (first-moment) linkages utilise the Vector Autoregressive model, studies on volatility transmission use volatility models, especially the GARCH family of models.

A number of common findings tend to emerge from relevant literature. Firstly, the dominance of the US stock market seems to be confirmed by most studies (see Asharnapalli *et al*., 1995; Hassan and Naka, 1996; Masih and Masih, 2001). Secondly most literature documents unidirectional transmission of returns and volatility from large stock markets to small stock markets. Thirdly, long-run comovement, returns and volatility linkages between developed and developing equity markets have been found to be very low or non-existent in the case of some small African stock markets (see Lamba and Otchere, 2001). A further interesting finding with regard to volatility, especially since the Asian and Latin American financial crisis, is that volatility in emerging equity markets is higher than that of developed counterparts (Tastan, 2005:3). With regard to the nature of volatility, the major finding has been that negative shocks (i.e. bad news) have more impact on volatility than positive shocks (good news) of the same magnitude i.e. asymmetry in volatility. We now review some of the empirical evidence, looking at developed equity markets, emerging equity markets and African equity markets.

2.3.1 DEVELOPED STOCK MARKETS[4]

An extensive body of relevant empirical literature exists for developed stock markets. With regard to the long run comovement of developed stock markets, the basic recent finding has been that stock market indices are cointegrated. As has been noted earlier, cointegration analysis dominates studies of this nature. One strand of literature has focused on investigating whether stock markets are driven by common macroeconomic factors. Following this hypothesis, Campbell and Hameo (1992) analyse US and Japanese stock market monthly data for the period 1971-1990 using a factor model. They established that common factors such as dividend-price ratio and interest rates help in forecasting returns for the two countries. In a similar study Roll (1992) utilises daily data for the period 1988-1991 for 24 countries. The author established that for all the countries studied, common factors like technical aspects of index construction, exchange rate regime and industrial structure strongly influence stock market behaviour. However, one setback of the methodology used in these two studies is that it is only useful from the perspective of short term diversification. Using Johansen's (1990) cointegration analysis with monthly and quarterly stock market indices data for the period 1974–1990, Kasa (1992) explored the same hypothesis focusing on U.S., Japan, England, Germany and Canada. The study showed that there is a common trend driving these countries' stock markets with Japan and Canada having the most and least important trend respectively.

A second set of studies analyse the impact of macroeconomic events on the long run comovement of stock markets. Of recent concern is that comovement among stock markets tends to increase after

[4] Although we will not put sub-headings, we will divide according to issues being discussed, starting with literature on long-run integration of stock markets followed by returns and volatility linkages of stock markets.

a crisis and this could lead to transmission of a harmful 'contagion' effect[5]. The procedure here involves dividing the sample of study into pre- and post-event periods and then applying the econometric methodology to investigate whether there has been any change in the long run trend of the stock markets. Although not explicitly testing the contagion hypothesis, Taylor and Tanks (1989) analysed the impact of the 1979 abolition of UK exchange rate controls on the degree of integration of the UK with the German, the Netherlands, Japanese and USA stock markets using the Engle and Granger (1987) cointegration analysis. Utilising monthly stock market indices data for the period 1973–1986, the authors found a long-run relationship between the markets only for the post-restriction period. However, a later study by Malliaris and Urrutia (1992) utilises the Granger Causality to establish that causality existed among USA, Japanese, Hong Kong, UK, Singapore and Australia stock markets both before and after the 1987 stock market crash. In analogy to Taylor and Tanks (1989), Asharnapalli et al (1995) used the Johansen (1989) cointegration approach to examine the impact of the 1987 US stock market crash on the integration of the US, German, Holland, UK and French stock markets. Their findings were in line with Taylor and Tanks (1989) except that the Japanese equity market was not cointegrated to any of the four equity markets raising the opportunity for portfolio diversification. The authors also established evidence in support of the contagion hypothesis. Similarly, Bonfiglioli and Favero (2005) utilised the Vector Error Correction model (VECM) to support the contagion hypothesis between the US and German stock markets during the 1987 stock market crisis, the 1998 Asian crisis and after the 11 September attacks.

Another strand of studies merely tests for cointegration of stock markets without necessarily considering the contagion hypothesis or the driving force behind stock markets. For instance, Bayers and Peel (1993) [in Glezakos *et al*., 2007] used the Johansen (1989) cointegration approach to establish that there was no long run relationship for US, UK, Germany, Japan and Holland using weekly stock market indices for the period 1979–1989. However, although the overwhelming goal of long-term institutional investors (e.g. long-term insurers and fund managers) would be to maximise long-term benefits from international diversification, they would also want to capture any short-term exploitable opportunities. Some studies have recognised this and have extended the cointegration analysis to include an analysis of the short-term dynamic interactions using the Error Correction model (ECM) or the Vector Error Correction model (VECM). Using the latter model and the Johansen (1989, 1991) approach, Hassan and Naka (1996) established that stock returns for US stock market influenced the Japanese, UK and German markets for the period 1984–1991 both

[5] See section 2.2.1 on the contagion hypothesis.

in the short and long run. They also confirm the existence of cointegrating vectors for all possible diversification strategies except for US-Japan-German and Japan-UK-German.

Studies on returns and volatility linkages have generally concluded that significant linkages exist between most developed markets. Simultaneous equations and the vector autoregressive (VAR) model have been the most commonly used in studying returns linkages. A problem with the former methodology is that it does not permit the simultaneous analysis of the dynamic interactions among more than two stock markets. A study by Koch and Koch (1991)[6] used simultaneous equations to establish that both contemporaneous and lead-lag relationships exist among different stock markets and that geographical proximity positively influences interdependence among stock markets.

Eun and Shim (1989) use the VAR methodology to investigate the mean linkages of nine international developed stock markets, namely Australia, Canada, France, Germany, Hong Kong, Japan, Switzerland, UK and the USA. They extend their methodology to an Impulse Response to trace out the dynamic responses of one market to another market's innovations. Their VAR findings reveal the existence of cross-country linkages with the impulse response showing that innovations from the US market are rapidly transmitted to other markets, while no market significantly explains US returns.

Some studies have looked at how the announcement of news impacts on returns and volatility linkages among stock markets. The hypothesis here is that good news and bad news have different impacts on returns and volatility and their transmission – a hypothesis normally referred to as the leverage/asymmetric effect. Using the multivariate EGARCH model with both opening and closing stock prices, Koutmos and Booth (1995) test this hypothesis for the US, UK and Japanese stock markets for the period 1986–1993. Simultaneously, the authors also tested the contagion hypothesis in volatility transmission by dividing the sample of study into pre- and post-1987 stock market crash. The findings showed evidence of support of both hypotheses. Koutmos (1996) also used the same methodology together with VAR to establish quite similar results for UK, France, Germany and Italy for the period 1986–1991. A study of quite similar nature and methodology by Cifarelli and Paladino (2005) utilised the daily exuberance index rather than the usual stock markets index for the US, UK and German stock markets[7] and employed a dummy variable for the 1997 Asian crisis. The authors' findings were in line with the former studies, except that the stock market exuberance index was found to be a better and more accurate modelling alternative to stock returns.

[6]This study employed a system of simultaneous equations to analyse the dynamic interactions and interdependencies among stock markets of the US, UK, Japan, Hong Kong and Singapore.

[7] The stock market exuberance index is derived from the standard portfolio arbitrage relationship. For a comprehensive discussion, derivation and computation of stock market exuberance index see Cifarelli and Paladino (2005:416-417).

Notwithstanding the fact that transmission exists between international stock markets, Ehrmann *et al.* (2005) provide further evidence that returns and volatility transmissions within domestic financial markets dominate transmissions across international financial markets. Using daily data and VAR methodology, they study the degree of mean and volatility transmission among financial markets, from both a domestic and an international setting. Consistent with the contagion hypothesis, they also established that international transmission of volatility tends to be stronger in times of crisis than tranquillity.

A further hypothesis that has been considered in empirical studies regarding returns and volatility linkages is whether the degree of stock market correlation strengthens in response to increasing globalisation and technological advancement. Berben and Jansen (2005) explore this hypothesis by investigating shifts in correlation patterns among international equity markets at both market and industry level for Germany, Japan, UK and US for the period 1980-2000. Using the bivariate GARCH model together with a Lagrange Multiplier statistic[8] with a smooth time varying correlation, the authors found that correlations among all the markets except Japan have doubled, with both the magnitudes and speeds of adjustment varying across countries and sectors.

2.3.2 EMERGING MARKETS STOCK MARKETS

Although South Africa is an emerging market, it will not be included in this section, but under the section for African stock markets. This is because most, if not all, the studies that analyse linkages between African markets and developed equity markets normally use a sample of African or sub-Saharan markets without specifically focusing on a single country. Thus, it is difficult to partition such a combined body of literature. Another justification for this decision is that the South African equity market occupies a pole position for studies that focus on integration and interdependence among African stock markets since it is Africa's largest and most liquid stock market.

Relevant empirical studies on emerging markets have increased especially after the 1990s Asian and the Latin American crises. Different issues tend to emerge from studies for emerging markets. The overwhelming majority of the studies on emerging markets have explored the contagion hypothesis. For instance, Forbes and Rigobon (1998) used cointegration analysis to find evidence against this hypothesis for a sample of emerging stock markets during crisis and the 1987 US stock market crash, the 1994 Mexican peso and the 1997 Asian crisis using cointegration analysis. However, Baig and Goldfajn (1998) compare the correlation between two Asian stock markets for pre-crisis and post-crisis using Pearson's correlation to establish evidence in support of the

[8] For a comprehensive discussion of this methodology see Berben and Jansen, 2005:830-835.

contagion hypothesis. Alternatively, two studies by Galick and Andrew (1999) and Ahluwalia (2000) focused on channels for contagion effects. Whilst, the former found that trade linkages, the latter established that macroeconomic similarities between countries are important channels for the transmission of contagion effects across equity markets.

Using the adjusted Pearson's correlation[9], Forbes and Rigobon (2002) document evidence against the contagion hypothesis while a quite similar study by Corsetti, Pericotti and Sbracia (2001) documents evidence of both interdependence and contagion. Darrat and Benkato (2003) use Johansen and Jesulius (1990) cointegration and the GARCH model with monthly data for the period 1986–2000 to analyse the extent to which the emerging Turkish market is integrated with the major developed markets of the US, Japan and Europe before and after the 1989 deregulation of Turkish financial markets. They found that integration of the Turkish equity market with the developed markets has strengthened in the post-liberalization period which was well in line with the objectives of the liberalization policy. With regard to volatility, they found that the Turkish stock market was excessively volatile, a feature that is common in emerging markets. However, contrary to the contagion, the authors found that volatility has considerably become less in the post-liberalisation period.

Although it has been generally established that developed stock markets influence emerging stock markets, the response of the latter to this influence has been established to be heterogeneous depending on the institutional and financial structure of a country rather than the economic fundamentals of the emerging market. For instance, Pagan and Soydemir (2000) utilise the VAR model together with impulse response to analyse the extent of interdependency between the US and the Latin American equity market for the period 1988–1994. Using weekly stock market indices they established that, due to different institutional and financial structures, Mexico's response to innovations from the US market is slower than those of Argentina, Chile and Brazil.

Some studies have explored the hypothesis that volatility and returns influence is unidirectional from developed influencing emerging stock markets. Using the discrete Walvet Decomposition[10] analysis with daily stock market indices for the period 1998–2001 , Lee (2001) provided evidence in support of this hypothesis for the influence of the US, Japanese and German and emerging markets on the Middle East and North Africa (MENA) region (i.e. Turkey and Egypt). In another study, Bala and Premaratne (2004) use both univariate and multivariate GARCH and VAR with daily stock market returns data for the period 1992–2002 to provide evidence against this

[9] The adjusted Pearson's correlation coefficient allows for the simultaneous measurement of both interdependence and contagion.
[10] For a description of this methodology see Lee, 2001.

hypothesis for the influence of the US, UK, Japanese and Chinese markets on the Singapore market. They also surprisingly found that the influence of Chinese stock market on the Singapore stock market was far more than that of the other three developed stock markets.

Despite the above findings in support of the unidirectional transmission hypothesis, volatility in emerging stock markets has been established to be more a function own- than cross-country innovations. This evidence is documented in a study by Worthington and Higgs (2002) for Asian developed (Hong Kong, Japan and Singapore) and emerging markets (Indonesia, Korea, Malaysia, Philippines, Taiwan and Thailand). Their study uses multivariate GARCH of BEKK (Baba, Engle, Kraft and Kroner) with weekly value weighted equity market indices for the period 1988–2000 to establish evidence in support of this issue and the hypothesis that spillovers are heterogeneous across emerging markets.

A recent study by Tastan (2005) employed a dynamic conditional correlation multivariate GARCH model to test whether countries with close trading and investment ties also have closely linked financial markets. This study analysed dynamic interdependence, price and volatility transmissions as well as financial integration between Turkey and developed markets of the US and European Union (EU) using daily data for the period 1990-2004. The author established the existence of significant price spillover between Turkey and the US, while small and insignificant price spillovers from European to Turkish stock markets. The author also found that the dynamic conditional correlation of the Turkish equity market with developed markets fluctuated considerably in the whole period (Tastan, 2005:17), with negative values detected at some periods. By dividing the period of study into pre- and post-custom union the author also found that correlation between the Turkish and all the other stock markets was stronger for post-union than the pre-union period.

2.3.3 AFRICAN STOCK MARKETS

Due to the poor level of development of equity markets in Africa previous researchers have put very little emphasis on analysing the interdependence among them or between them and the developed equity markets. However, since the late 1980s, most sub-Saharan African governments embarked on International Monetary Fund (IMF) and World Bank sponsored structural adjustment programmes (SAP). These programmes involved, amongst others, deregulation of the financial system, liberalization of financial markets, development of equity markets, privatisation of government enterprises and removal of capital controls which allowed the easy flow of capital from industrialised countries. This coupled with the relaxation of foreign exchange controls, has increased participation of foreign investors in developing stock markets. As Piesse and Hearn (2005:36) note, financial reporting and dissemination of stock price information have also improved. Thus, bad information in equity markets can be disseminated to the world as fast as good information and this may result in sudden capital flight and increased volatility. Participation by foreigners in African stock markets has remained quite low due to pessimism about social, economic and political uncertainties (Piesse and Hearn, 2005:37).

The South Africa equity market is the oldest, largest and most liquid equity market in the continent. Although other African stock markets have shown considerable growth, most of them are still quite small. Despite the fact that they have different sizes, most African stock markets tend to share common institutional characteristics such as weak regulatory structures, commercial and legal frameworks. Post-independence central planning ideological framework, lack of liquidity in financial markets, lack of proper legal protection against creditors and poor regulation and monitoring, and general lack of stock market culture and awareness are the major factors blamed for the continued underdevelopment of most of the African equity markets (Piesse and Hearn, 2005:40). Nevertheless, following the implementation of the SAP as well as increased political and economic integration (e.g. African Union, NAPAD, SADC, etc.) one would expect that the equity markets in sub-Saharan African are now becoming integrated with each other and possibly with the world major equity markets.

Mixed findings have emerged from the few existing empirical studies on African stock markets. One common finding has been that the African equity markets are generally segregated from each other and from the world equity markets, which is an indication that they are mostly influenced by domestic factors. Notable exceptions are South Africa and Namibia, which are linked to each other and also influenced by the US and UK equity markets. This evidence is documented by Lamba and Otchere (2001) in a study that analysed the linkages among African stock markets and with the global market using VAR and impulse response. A further finding by the authors was that Ghanaian, Namibian and SA markets were linked to the resource-based stock markets like Australia and Canada influences.

However, using the Johansen and Juselius (1992) cointegration approach and Granger Causality test and monthly stock returns, Piesse and Hearn (2002:1711) found that Southern African Customs Union (SACU) equity markets are cointegrated. A surprising finding from the Granger causality test is that causality runs from the Namibian to the South African stock market. The authors attribute this to the presence of common regional factors that tend to affect Namibia more than SA, which then spillover to the more open South Africa equity market (Piesse and Hearn, 2002:1721).

On the other hand, Collin and Biekpe (2003) analysed the extent of integration of African stock markets with a view to assessing their vulnerability to Asian stock market crisis of 1997 using the adjusted Pearson's correlation coefficient of Forbes and Rigobon (2002). They found that with an exception of Egypt and South Africa, the African stock markets are not vulnerable to contagion. The authors also established limited evidence of causal relationship among African stock markets except among regional blocks, which they attributed to trade and economic links rather than investors' behaviour (Collins and Biekpe, 2003:193).

The nature of volatility within and across African stock markets has also been empirically examined. For instance, using a time-varying asymmetric moving average threshold GARCH (asymmetric-MA-TGARCH) model and daily stock indices for SA, Nigeria and Kenya for the period 1985-1998, Ogum (2002) found evidence that both conditional mean and conditional variance respond asymmetrically to past innovations. However, in the case of conditional mean, the asymmetry is reverse i.e. good news has greater impact on return than bad news of the same magnitude. Similarly, Piesse and Hearn (2002) use the exponential GARCH model of Nelson (1991) with weekly data for the period 1997-2000 to establish evidence of bidirectional transmission of asymmetric volatility among some of the sub-Saharan equity markets. However, their overall finding was that due to lack of liquidity and limited domestic participation most of the sub-Saharan equity markets were not integrated.

2.4.0 CONCLUSION

This chapter explored diverse issues regarding the linkages of stock markets. Firstly importance of understanding of linkages of stock markets, both from a policymaking and an investment analysis point of view, were highlighted. To provide a theoretical backing to the empirical literature, the nature of linkages between stock markets was then analysed and these were grouped into two broad groups as follows: (i) contagion or interdependence (ii) symmetric or asymmetric. The empirical literature regarding the linkages of stock markets was then reviewed.

The empirical literature was grouped into three sections focusing on relevant literature for developed, emerging and African stock markets respectively. Furthermore it has been noted that the studies on linkages of stock markets can be distinguished into three categories depending on the issue being looked at. One issue looked at by empirical studies is the long-run comovement of stock market indices with a view to evaluating the possibility of portfolio diversification. The second and third issues are returns and volatility linkages among equity markets. Due to globalisation, financial innovation and financial liberation, the majority of recent literature documents increased linkages between stock markets. Generally, the bulk of relevant empirical literature is for developed countries, with emerging markets increasingly getting attention after the Asian and Latin American financial crises and very little on African stock markets. A major finding is that most developed stock markets are linked both in terms of long-run index comovement and return and volatility transmission, whilst the findings are mixed for emerging stock markets. Most studies tend to support that there is unidirectional flow of returns and volatility from large to small stock markets. A few recent studies (see Bala and Premaratne, 2004) established the existence of bidirectional transmission. Such findings also cast a cloud of doubt over an earlier common finding that the US stock market dominates in return and volatility transmission and that no single stock market significantly influences its returns or volatility. Linkages among emerging financial markets have been seen to increase during or after times of financial crisis and with increased globalisation and financial liberalisation; this raises dangers of outward capital flight.

As for African stock markets, it has been noted that empirical studies remain extremely scanty. Findings that emerge from the existing few are that there is very little correlation between African stock markets and developed markets as well as among them. It has also been empirically established that the South African equity market influences some other African stock markets, especially those in the SADC region.

However, the South African stock market has undergone a number of institutional changes which have not been considered in any previous studies. These changes might have affected the size, liquidity and efficiency of the JSE as well as integration into the global equity markets and there is need to re-examine it. As evident from the review, existing relevant studies for Africa focus on either returns linkages or long term comovement between African and other stock markets. There is need for a study which looks at long run comovement, returns linkages and volatility transmission at the same time. A number of hypotheses, for instance the behaviour of volatility over time, the risk premium hypothesis and the bidirectional transmission of shocks hypothesis, have not been considered by existing studies. Thus this study attempts to fill these gaps.

The next chapter compares the stock markets being studied with a view to establish if there are any possibilities for linkages of the stock markets. Together with this chapter, the next chapter lays foundation for the empirical analysis.

CHAPTER THREE:
A COMPARISON OF THE STOCK MARKETS[11]

3.0 INTRODUCTION

This chapter explores three issues that may be of concern to the linkages of stock markets. The chapter is divided into three sections as follows: Section 3.1 compares the markets with regard to size, liquidity and foreign listings. Section 3.2 analyses the trends of the stock market indices, linking these trends to the major macroeconomic shocks. Section 3.3 looks at the trading sequence of the markets. The size, liquidity and number of foreign listed companies may have implications in the manner in which stock markets are linked to each other. On the other hand the linkages of the stock markets may be reflected by the behaviour of the stock market indices. Finally, lead-lag relationships among the trading times of the stock markets may have implications on the time and speed of the influence of one stock market on another. For instance, the fact the US stock market trades behind all the other stock markets under study may imply that news from the US stock market will only impact on the other stock markets on the next trading day.

3.1 SIZE, LIQUIDITY AND FOREIGN LISTINGS[12]

In this section we compare the stock markets under study with regard to size, liquidity and foreign listings. Comparison of the stock exchanges in these respects might be valuable in a number of ways. Firstly, the size and liquidity of a market has implications for its efficiency (see Mabhunu, 2004:13) and thus the speed at which it reacts to news from the macroeconomic environment or from other stock markets. In this regard, it is reasonable to hypothesise that if two exchanges are very efficient, then they may be very responsive to news from international economic shocks, hence may move in the same direction. On the other hand, if a market is efficient and another inefficient, it would imply that the former will be more responsive to news both from macroeconomic and from other stock markets than the latter. Finally, the presence of foreign listed companies might have implications on return and volatility transmission among international equity markets. This is because of the fact that foreign companies that are listed in more than one equity market may adjust their holdings in different markets should events that affect equity markets differently occur.

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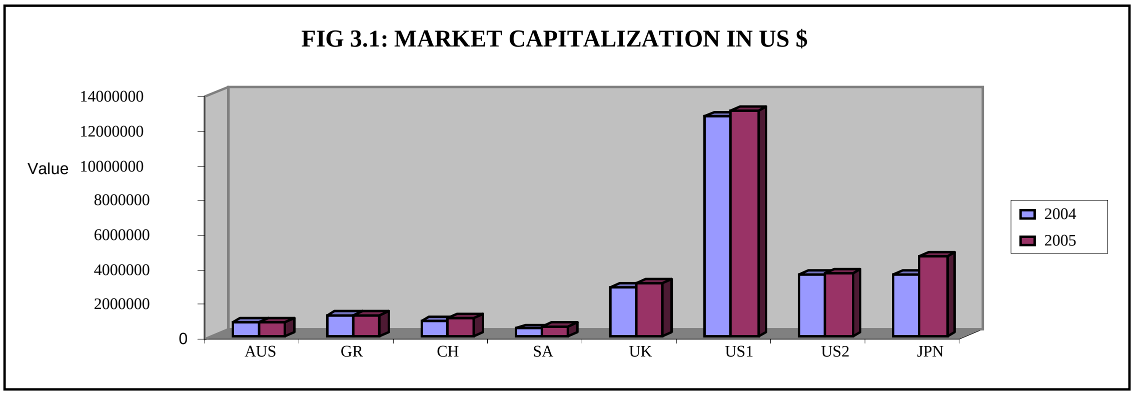
[11] It should be noted that here we do not look at the historical, development and regulation of the exchanges but we merely compare them with a view to find whether any of their characteristics have implications for comovement and returns and volatility transmission.

[12] Note that all the statistics in this section were sourced from the Federation of World Stock Exchange, 2007 website; [http://www.world-exchanges.org/WFE/home.asp?action=document&menu=195]

We used market capitalisation as an indicator for the sizes of the stock markets. This indicator is computed by multiplying the total number of shares on issue by the respective share prices at a given time and it provides value of the stock market at that time. The higher the market capitalisation the larger the stock market under consideration. Turnover velocity has been used as an indicator for liquidity. This indicator is computed by dividing domestic shares turnover by market capitalisation and then multiplying the ratio by 12 month in order to annualise it. Generally, a higher percentage indicates that a stock market is more liquid. The indicator for foreign listing is the number of listed foreign firms. This indicator is shown in Table 3.1, together with the number of domestic listed companies and total number of listed companies for each stock exchange.[13]



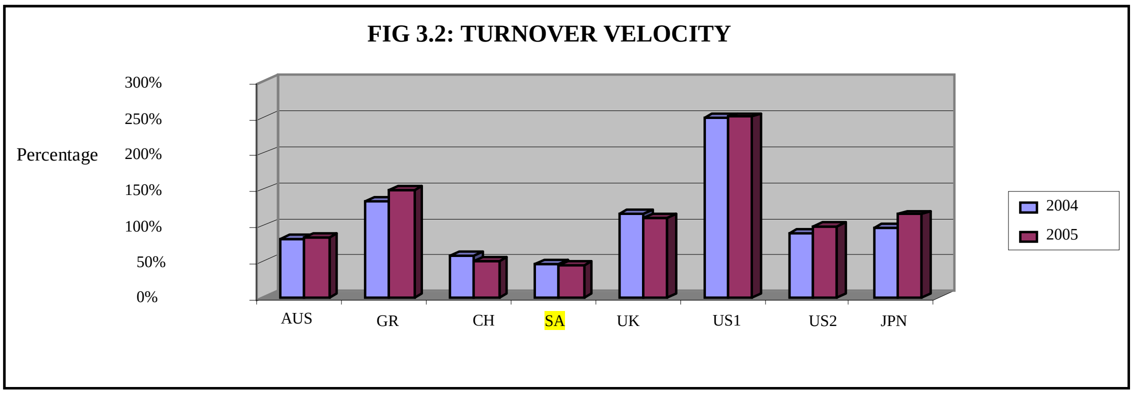


TABLE 3.1: NUMBER OF LISTED COMPANIES

	2004			2005		
EXCHANGE	**TOTAL**	**DOMESTIC**	**FOREIGN**	**TOTAL**	**DOMESTIC**	**FOREIGN**
AUS	1,583	1,515	68	1,714	1,643	68
GR	819	660	159	764	648	159
CH	1,096	1,086	10	1,135	1,126	10
SA	389	368	21	373	348	21
UK	2,837	2,486	351	3,091	2,757	351
US1	2,293	1,834	459	2,270	1,818	459
US2	3,229	2,889	340	3,164	2,832	340
JPN	2,306	2,276	30	2,351	2,323	30

[13] In this chapter, the US market is represented by the New York and NASDAQ stock markets.

Source: Federation of World Stock Exchanges, 2007

It is evident from Fig 3.1 that the US stock market is by far the world's largest stock market in terms of market capitalisation. The Japanese stock market [represented by the Tokyo Stock Exchange (TSE)] is the second largest, while the UK stock market [represented by the London Stock Exchange (LSE)] is the third largest. The German stock market [represented by the Frankfurt Stock Exchange (FSE)] and Chinese stock market [represented by the Hong Kong Stock Exchange (HSE)] occupy the fourth and the fifth positions respectively. The Australian stock market [represented by the Australian Stock Exchange (ASX)] and the South African stock market [represented by the Johannesburg Securities Exchange (JSE)] take the sixth and seventh positions respectively.

Fig 3.2 gives turnover velocity, which is a measure of liquidity of the stock exchanges. Like in the case of market capitalisation, the NYSE is ranked first with the FSE and LSE taking the second and third positions respectively. The TSE, NASDAQ, ASX, HSE and JSE respectively follow in liquidity. Although, the JSE is the most liquid African stock exchange, it is only ranked 32nd in the world liquid rankings. Since stock market liquidity improves the efficiency of a stock market (Mabhunu, 2004:13) it is our opinion that the more liquid a market the more it will be integrated into the global stock markets.

Looking at the number of listed companies, the LSE tops the list, with TSE, NYSE, and ASX also featuring in the top five. The JSE is by far the smallest of all the markets under study with regard to the number of listed companies. Out of the listed companies, the NYSE has the largest number of foreign companies, followed by the LSE, NASDAQ and the FSE. The JSE has shown an increase in foreign listed companies between 2004 and 2005. As already been argued the availability of foreign companies on a stock exchange may have implications for linkages of stock market due to the fact that investors in such companies may adjust their portfolios in these companies following some macroeconomic developments in one of the countries where they are listed. In light of this, it is important to note the LSE and the JSE have an agreement which contemplates the creation of an international board whose listing requirements will comply with the listing requirements of the UK (JSE, 2007). SA companies complying therewith may be admitted to trading on the JSE and the LSE provided they comply with the UK admission requirements. Securities allowed to trade in this manner will be regarded as having a primary listing on both exchanges. Given this we would expect strong interlinkages between the SA and the UK stock markets.

3.2 TRENDS IN THE STOCK MARKETS PRICE INDICES

FIG 3.3: STOCK MARKET INDICES

As evident from Fig 3.1, there seems to be comovement of indices along continental lines. For instance the UK, and the German stock market indices seem to reflect quite a similar picture. The Chinese and the Japanese stock markets also seem to show similar long run trends. This could be due to the fact that continental exchanges are affected by similar macroeconomic factors. However, it is also clear from Fig 3.1 that the long run trend of the US stock market index seems to be in line with the two European stock markets, the UK and German stock markets. The Australian and the South African (SA) stock market indices also seem to show relatively comparable trends. This may be due to the fact that the two stock markets are largely resource based.

Another way of examining the possibility of existence of linkages is to consider the reactions of the stock markets to the two major events that occurred within the period of study. We focus on the Asian Crisis of 1997 and the September 2001 attacks on the US. The UK, Japanese, Chinese and South African stock markets seem to have been affected by the Asian crisis. This is evident from the fact that their indices experienced a sharp decline in 1997. The Chinese and South African stock market indices show a sharper downward trend than the two former during the crisis period, which seems to validate the fact that emerging markets are more affected through the contagion effect during a financial crisis. On the other hand, all stock markets seem to have reacted to the September 2001 attacks. The US, UK, German, Chinese and Japanese stock markets show sharper and persistent declines between late 2001 and 2004. This could indicate that a major unexpected shock in a large economy like the US will affect both the US and other world stock markets strongly and persistently. The persistence could also be due to the pessimism created by the 2003 invasion of Iraq. In 2004, all the indices fell and since then there has been an upward trend in all the indices, although it is not smooth.

There are some general issues and questions that can be raised by merely observing the behaviour of the indices. Firstly, linkages seem to be strong along continental groupings. Secondly, the SA and Australian markets seem to move together, possibly due to the fact that they are both resource-based. Thirdly, while most developed stock markets seem not to have reacted to the Asian crisis, the emerging markets did. The questions we pose are: Does the behaviour of the stock markets have implications for linkages of the markets? Could it be that the largest stock market, the US has the greatest influence on other stock markets, as most empirical literature suggests? Could the fact that the Australian stock market index seems to move with SA's be an indication that the two are closely linked? And, finally, does the fact that most of the market seemed to react to the 2001 September attacks evidence that influence only runs from the US to other stock markets? All these questions cannot be answered by the graphical plots of the indices but require empirical examination.

3.3. SEQUENCE OF TRADING

The comparison of trading times could help determine the lead-lag relationships among the exchange. As will be seen later, the sequence of trading times is also important in specifying our Vector Autoregressive (VAR) methodological framework. Table 3.2 below shows the trading-sequence times of the exchanges.

As evident from the table, three trading times can be distinguished into three time zones: the Asian time zone, the European time zone and the American time zone respectively. Australia, China and Japan lie in the first time zone, Germany, SA and the UK lie in the second zone and the US in the third zone. We have put SA into the European zone because SA is only an hour ahead of Europe. From Table 3.2, it is clear that trading time on the SA equity market lies between the Asian and the American zone. The implication of this is twofold. Firstly, since the Asian stock markets trade ahead of SA, events that take place in the Asian stock markets are reflected in the SA equity market as soon as it opens. Secondly, since the US is behind the SA, events that take place in the US will only affect the SA on the next trading day. As will be seen in the next chapter, this has implications for some parts of the analytical framework.

TABLE 3.2: TRADING SEQUENCE OF THE EXCHANGES[14]

JOHANESBURG TIME	LONDON TIME	NEW YORK TIME	ACTION
Monday 01:00	Monday 00:00	Sunday 19:00	Trading starts in Australia
Monday 01:00	Monday 00:00	Sunday 19:00	Trading starts in Japan
Monday 03:00	Monday 02:00	Sunday 21:00	Chinese Stock markets open
Monday 08:00	Monday 07:00	Monday 02:00	Trading starts in South Africa
Monday 08:00	Monday 07:00	Monday 02:00	Trading closes in Australia
Monday 09:00	Monday 08:00	Monday 03:00	Trading closes in Japan
Monday 09:00	Monday 08:00	Monday 03:00	German and UK open
Monday 10:00	Monday 09:00	Monday 04:00	Trading closes in China
Monday 14:00	Monday 13:00	Monday 08:00	Trading closes in US
Monday 17:00	Monday 16:00	Monday 12:00	Trading closes in South Africa
Monday 19:00	Monday 18:00	Monday 13:00	Trading closes in German and UK
Monday 22:00	Monday 21:00	Monday 16:00	Trading closes in US
Tuesday 01:00	Tuesday 00:00	Monday 19:00	Trading starts in Japan

Source: SAIFM (2003:39)

3.4.0 CONCLUSION

This chapter has provided a comparison of the stock markets with regard to three issues: size and liquidity, trends of stock market indices, and trading times of the exchanges. Section 3.1 compared size and liquidity using market capitalisation and velocity turnover as well as discussing the implications of size and liquidity on linkages of stock markets. Section 3.2 examined the trends in the stock markets by plotting the stock market indices for the different stock markets. A number of observations were made from the graphs. Firstly, we observed that indices of continental stock markets seem to move together. Secondly, we observed that the Chinese, an emerging stock market, seems to have overreacted to the 1997 Asian crisis. A third observation was that all stock markets reacted to the September 11 attacks on the US. From the size and liquidity of the exchanges as well the behaviour of the indices, we raised a number of issues and questions that will be answered through empirical analysis in Chapter 5. Finally Section 3.3 highlighted the trading sequence of the exchange and the implication of this for the lead-lag relationships among exchanges and the analytical framework. Together with Chapter 2, this chapter laid down the foundation for the empirical analysis which will be discussed in more detail in the next chapter.

[14] Note that the table provided by SAIFM (2003) is for the trading day of the world foreign exchange markets. Therefore we have slightly altered it to suit the world equity markets.

CHAPTER FOUR:
METHODOLOGY AND ANALYTICAL FRAMEWORK

4.0 INTRODUCTION

This chapter sets out the analytical framework that is used to provide answers to the objectives set out in Chapter 1. The chapter also discusses the proxies and data used in this study. As noted earlier, the study examines the following three issues: the long run comovement, returns linkages and volatility transmission between the SA and world stock markets. Following other empirical studies (see for example Allen and McDonald, 1995; Koutmas and Booth, 1995; Pagan and Soydemir, 2000; Piesse and Hearn, 2002; Lamba and Otchere, 2001; Bonfiglioli and Favaro, 2005) we use the Johansen cointegration to analyse the long run comovement, Vector Autoregressive (VAR) to examine return linkages, and the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) and VAR to analyse volatility and volatility linkages.

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

4.1 LONG RUN COMOVEMENT: JOHANSEN COINTEGRATION APPROACH

4.1.1 TESTING FOR STATIONARITY AND THE COINTEGRATION FRAMEWORK

The standard ordinary least squares (OLS) require that all the series are integrated of order 0 [*I (0)*], i.e. the series stationary at level. Gujarati (2005:496) describes a stationarity stochastic process as containing constant mean and variance overtime and a covariance that is not serially correlated. A process of this nature is normally referred to as a ‘white noise’. Stationarity of series is important for two reasons. Firstly, if series are stationary then it is possible to make forecasts. Secondly, stationarity minimises the possibility of spurious OLS regressions.

It is a necessary, although not sufficient, condition for cointegration that all the series to be analysed are integrated of the same order (more than zero) or that all series contain a deterministic trend (Granger, 1986). There are several methods of testing for stationarity, for instance visual plots of data, the autocorrelation function, unit root test and those that directly test for stationarity, among others. This study uses one unit root test (the Augmented Dickey Fuller) and one stationarity test, the Kwiatkowski *et al.* (1992) test. Since the two techniques are very common and have been employed by several empirical studies, the theoretical underpinning behind them will not be discussed here[15].

A combination of two I(1) series is normally an I(1) and generally if series of different order of integration are combined, then their combination will take the highest order series [i.e. a combination of I(1) and I(2) is an I(2)] (Brooks, 2002:387). However, if the series are cointegrated, this might not be the case. For instance, if it has been shown that a combination of I (1) is cointegrated, then this combination is I (0).

Partly following Allen and McDonald (1995), this study uses the Johansen (1988) and Johansen and Juselius (1990) cointegration approach. This approach applies a VAR model assuming that the errors are white noise (Maddala and Kim, 1998 and Aziakpono, 2006b) and is generally specified as follows:

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

Where X_t is a vector of the I (1) stock market indices, ΔX_{t-1} are all I(0), Π gives the number of cointegrating vectors[16], z_t is a vector of deterministic variables and k is a finite autoregressive lag order used for the estimation. If *Π=r,* then *r* possible stationary linear combinations do exist and *n x r* matrices of *α* and *β* such that

$$\Pi = \alpha\beta^1 \qquad [4.2]$$

Where α represents the speed of adjustment matrix and β is a matrix of long run coefficients.

The Johansen cointegration approach makes use of two likelihood ratio (LR) test statistics to determine the rank of the Π matrix, the number of cointegrating vectors. These statistics are the trace (λ_{trace}) and the maximum eigenvalue ($\lambda \max$) and they can be specified as follows:

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

And

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

Where r denotes the number of cointegrating vectors under the null hypothesis and $\hat{\lambda}_i$ represents the estimated value for the i^{th} ordered eigenvalue from the Π matrix (equation 4.4). While the trace

[15] For a comprehensive discussion of the theoretical underpinnings and the empirical issues concerning the ADF and KPSS, see for instance Brooks (2002).

[16] Π = 0, if there are cointegrating vectors. Assuming that cointegration exists then the highest value assumed by Π_i will have a rank of n-1, where n is the number of X_t in the VAR equation.

statistic consecutively 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 maximum eigenvalue tests the null hypothesis that there are r cointegrating vectors against an alternative of $r+1$ (Brooks, 2002:405).

The implication of cointegration is that although series may be individually non-stationary, their linear combination may be stationary. Thus, they may influence each other in the long run. In the context of this study, if two stock market indices are individually nonstationary, but are cointegrated, then it would imply that the two stock markets move together in the long run and thus the possibility of gains from international diversification may be limited. Furthermore, the existence of cointegration between two stock markets "suggests that one market will help predict the others since a valid error correcting representation will exist" (Allen and McDonald, 1995:35). This is in contrast to the weak form Efficient Market Hypothesis (EMH). Cointegration between series can also be viewed as a long term or equilibrium phenomenon, since the cointegrating series may deviate from the relationship in the short run, but would return to equilibrium in the long run (Takaendesa, 2005:95). Thus, an investor in stock markets could still capitalise by making short-term rather than long-term diversification strategies.

In this study, cointegration analysis will be carried out in two stages. Firstly, bivariate cointegration analysis will be used to examine the long run relationship between the SA equity markets and each of the stock markets under study. Based on the principle that unsystematic risk is a decreasing function of the number of assets included in a portfolio (Howells and Bain, 2005), possible portfolios will be chosen and tested for long run relations using multivariate cointegration. The choice of these portfolios will primarily be based on the importance of the stock markets under consideration from a SA investor's perspective.

After identification of the number of cointegrating vectors in the model, a Vector Error Correction Model (VECM) [equation 4.4] can now be estimated by specifying the number of cointegrating vectors, trend assumption used in the previous step and normalising the model on the true cointegrating relation(s). The VECM framework restricts the long run behaviour of the endogenous variables to converge to their cointegrating relationships, while allowing for short run adjustment dynamics. The final step is to perform diagnostic checks on the residuals from the estimated VECM to ensure that they are white noise. Only the normality test will be used for diagnostic testing in this study.

4.2.0 EXAMINING RETURNS LINKAGES

As noted in Chapter 2, the existence of returns and volatility linkages among stock markets has been widely documented (see for example, Pagan and Soydemir, 2000; Lamba and Otchere, 2001; Brooks and Ragunathan, 2004). Different studies employ different econometric methodologies, for example the Granger causality (see Malliaris and Urrutia, 1992) and simultaneous equations (see Koch and Koch, 1991). The problem of the former is that the existence of significant Granger causality does not necessarily imply that there is a causal relation between stock markets. On the other hand, simultaneous equations can only be useful if there are only two stock markets under study and it also has problems with regard to identification (Brooks, 2003). The VAR has been suggested as a better alternative to these methodologies, thus this study will use this approach for examining return linkages.

4.2.1 VECTOR AUTOREGRESSIVE (VAR)

In order to understand the returns and volatility comovement, it is important to analyse the market dynamics, transmission and propagation mechanism driving these markets. A model that clearly shows how returns and volatility are transmitted from one market to another in a recognised fashion, as well as ensuring that multilateral interactions are simultaneously analysed, is necessary. The Vector Autoregressive (VAR) model would be among one of the most appropriate models.

Developed by Sims (1980), the VAR model can estimate a dynamic simultaneous equation system without putting any prior restrictions on the structure of the relationships. Because it does not have any structural restrictions, the VAR system can enable the estimation of reduced form of correctly specified equations whose actual economic structure may be unknown. This is an important feature in empirical analysis of data since structural models are normally misspecified.

Our study will express the VAR model as follows:

$$X_t = C + \sum_{s=1}^{m} A_s X_{t-s} + \varepsilon_t \qquad [4.5]$$

Where X_t is a 7 x 1 column vector of equity market returns for the seven stock markets under consideration, C is the deterministic component comprised of a constant, A_s are respectively, 7 x 1 and 7 x 7 matrices of coefficients, m is the lag length and ε_t is the 7 x1 innovation vector which is uncorrelated with all the past X_s.

The VAR analysis is a useful tool to test for and examine spillovers and linkages between stock markets. However, the fact that there are so many coefficients raises problems regarding interpretation. Of particular concern here is that the signs coefficients of some of the lagged variables may change across lags. Together with the interconnectivity of the equations, this could make it difficult to see how a given change in a variable would impact on the future values of the variables in the VAR system (Brooks, 2002:338). Furthermore, the VAR estimates do not allow us to determine very much about the transmission of shocks across the system or the period of time that it takes these shocks to work through the system. Thus, the VAR model is normally extended with block exogeneity, impulse responses and variance decompositions functions in order to alleviate these problems. These are discussed below.

4.2.2 BLOCK EXOGENEITY/VAR GRANGER CAUSALITY

The block exogeneity test attempts to separate the set of variables that have significant impacts on each of the dependent variables from those that do not. This is done by restricting all the lags of particular variables (X_ts) to zero and then testing for the significance of eliminating these variables. This joint significance test follows an F-distribution (Brooks, 2002:339), and is analogous to testing for Granger causality (Granger, 1969). This test is based on testing the validity of a set of zero restrictions on some of the parameters in the VAR equation [4.5]. In this study we use the block exogeneity test for testing which of the stock markets truly influence SA returns and volatility. Block exogeneity will also be used to identify which of the stock markets are the most exogenous and endogenous in returns and volatility linkages. Finally, this test will allow us to determine whether the SA equity market truly influences volatility and returns of other stock markets.

4.2.3 IMPULSE RESPONSE ANALYSIS

This traces out the responsiveness of a dependent variable to shocks to each of the other variables in the VAR framework. In the context of this study, the impulse response function answers questions with regard to response of the SA equity market to a one standard error unit shock in any of the developed and emerging equity markets being studied. In this analysis, the sign, magnitude and persistence of responses of one market to shocks in another stock market are captured. Since our study utilises daily data, the finding of 'contemporaneous' response could be interpreted as a measure of the degree of informational efficiency of the SA equity markets (Bala and Premaratne, 2004).

As noted by Lutkepohl and Saikkonen (1997:130) and Aziakpono (2006a:7), if the process [4.5] is white noise, then the estimated VAR can be inverted into a moving average representation whose coefficients are forecast error impulse responses. The moving average takes the following form:

$$X_t = C + \sum_{s=0}^{k} B_s \varepsilon_{t-s} \qquad [4.6]$$

Where X_t denotes a linear combination of current and past one step ahead forecast error or innovations. In the context of this study, the coefficient B_s can be interpreted as the response of one stock market returns to a one standard error shock of any of the markets under study s periods ago. Like in equation 4.5 the ε_t's are also serially uncorrelated although they may be contemporaneously correlated.

As noted by Aziakpono (2006:8), the impulse responses in [5.6] are commonly estimated using the generalised impulse response proposed by Koop, Pesaran and Potter (1996) and Pesaran and Shin (1998), and the Cholesky decomposition proposed by Sims (1980). Whilst the former has the advantage over the latter in that it requires orthogonolization of innovations and does not vary with the ordering of variables in the VAR (Pesaran and Shin, 1998:17 and Aziakpono, 2006:8), results from the two methods coincide if the shocks are uncorrelated. This study uses the Cholesky decomposition estimation criterion and the markets will be othorgonolized according to their trading sequence.

4.2.4 VARIANCE DECOMPOSITION ANALYSIS

The Variance Decomposition analysis can also be utilised in analysing the returns and volatility linkages between the equity markets. Unlike the impulse response, which traces the effects of a shock to one endogenous variable on other variables in the VAR framework, variance decomposition splits the variations in one stock market into component shocks in the VAR. By so doing this analysis gives information about the relative importance of error/innovation of each stock market in explaining other stock markets included in the VAR system. Stated differently, variance decompositions show the proportion of the movements in the explained stock market that are due to its 'own' innovations, against those from other stock markets. Empirical literature widely documents that own series innovations tend to explain most of the forecast error variance of the series in the VAR (see Brooks, 2002:342; Lamba and Otchere, 2001:18).

In this study, we use variance decomposition to measure the proportion of the movements in any of the stock markets that are explained by other markets. Of particular concern is how much of variations in SA's stock market returns and volatility can be explained by innovations of world stock markets. This will help us determine which of the world stock markets has the greatest influence on the returns and/or volatility of the SA market. Variance decomposition will also help us determine whether the SA market is either largely exogenous or endogenous. This will be inferred from the extent to which own-innovations can explain variations in SA stock market returns and volatility.

4.3.0 ANALYSIS OF VOLATILITY AND VOLATILITY LINKAGES

Financial data is characterised by excess volatility, volatility clustering and leverage effects. These properties cannot be properly captured by time series models and thus volatility models have been suggested as the most appropriate alternative. The Autoregressive Conditional Heteroscedasticity (ARCH) of Engle (1982) and the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) of Bollerslev (1986), and different extensions to these models have been extensively used in recent empirical studies. The application of the ARCH methodology on a single return series, involves 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. Maximum Likelihood Estimations are then used to estimate the coefficients of the model. As documented by Hurditt (2004:6) normal ARCH and GARCH models have been found to be generally good in estimation of in-sample parameters and, when the appropriate volatility measure is used, reliable out-of-sample volatility forecasts can be obtained. However, there are a number of problems with the symmetric ARCH and GARCH models. Firstly, they cannot guarantee non-negativity of the conditional variance, in which case it becomes necessary to put restrictions on the parameters. Secondly, under certain circumstances these models fail to account for volatility clustering and excess kurtosis in financial series. This is the case if the series' volatility is more persistent than that captured by the standard GARCH and ARCH models (Tse, 1998:49). Thirdly, the model fails to allow any direct feedback between the mean and conditional variance (Brooks, 2003:469). Lastly the models cannot capture asymmetry in volatility.

Because of these weaknesses, different extensions have been suggested to the basic models. Some of the extensions to these models include the GARCH in mean (GARCH-M), Exponential GARCH (EGARCH), and Glosten, Joganathan and Runkle GARCH (GJR GARCH)[17]. Whilst the GARCH-M was developed to account for the issue of lack of direct feedback between the conditional variance and the mean, the latter two were developed to deal with the volatility asymmetry. A number of empirical studies have used the asymmetric models to establish that volatility in financial markets is asymmetry (see for example Koutmas and Booth, 1995 and Piesse and Hearn, 2002).

In order to address the objectives regarding transmission of volatility among the equity markets, we first analyse the volatility of each of the stock markets using the GARCH, EGARCH and GJR GARCH models. We then generate conditional variance series using the most appropriate of these three models. These conditional variance series will serve as a proxy for volatility for each of the stock markets. Partly in line with an approach followed by Brooks and Ragunathan (2003:750-752),

[17] Note that the GJR GARCH can also be referred to as the TARCH model

the conditional variance series will then be analysed using the VAR together with impulse response and variance decomposition to examine the transmission of volatility among the stock markets.

Below is a discussion of the models and the procedures that will be used to determine volatility in each of the stock markets and volatility transmission among the stock markets. However, since VAR, block exogeneity, impulse response and variance decomposition have already been discussed, they are not described again.

4.3.1 THE MEAN EQUATION AND THE GARCH-IN MEAN EXTENSION

The starting point of modelling volatility is to specify an appropriate mean equation. The mean equation can be a standard structural model, an autoregressive (AR) model or a combination of these. Since our aim is to generate conditional variance series for each of the stock markets, it will be inappropriate to use a structural model. A number of studies on volatility employ a mean model that regresses the depended variable on a constant (see for example Takaendesa *et al*., 2006). An important feature for an appropriate mean equation is that it should be 'white noisy' i.e. its error terms should be serially uncorrelated. Following previous studies (e.g. Takaendesa *et al*., 2006), this study employs the following mean equation:

$$y_t = \mu + \varepsilon_t \qquad [4.6]$$

Where y_t is returns for each of the stock markets and μ is a constant. The estimated model will then be tested for autocorrelation using the Durbin Watson (DW) test[18]. If there is evidence of autocorrelation, lagged values of the dependent variable will be added to the right hand side of [4.7] until serial correlation is eliminated. The appropriate mean equation will also be tested for ARCH effect before proceeding to estimating volatility models.

An important hypothesis that has prevailed in financial markets is that more risky markets have higher returns than less risky ones (see Brooks, 2002). This is because risk-loving investors would want to be rewarded for taking higher risk. The GARCH-M model provides a practical way of modelling risk and return in such a manner that this hypothesis could be empirically investigated. Proposed by Engle, Lilien and Robins (1987)[19], the GARCH-M model is modelled by extending the above mean equation as follows:

$$yt = \mu + \delta h_{t-1} + \varepsilon_t \ , \qquad \varepsilon_t \sim N(0, \sigma_t^{\,2}) \qquad [4.7]$$

Where y_t denotes mean returns, h_{t-1} is a lagged conditional variance term and ε_t is the residual term. A conditional variance equation (in the form of GARCH, EGARCH or TARCH) is then entered

[18] Note that critical DW is 2. If the test statistic is below 2 then there is evidence of positive autocorrelation and when it is above 2 there is evidence of negative autocorrelation.
[19] In Brooks, 2003:480.

into the above equation [4.12] and the parameters are estimated. The parameter δ is interpreted as risk premium, and if it is positive and statistically significant, then increased risk, given by an increase in the conditional variance, leads to a rise in the mean return.

4.3.2 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 motivation behind the LM specification of heteroskedasticity was the observation that the magnitude of residuals for many financial time series tends to be related to the magnitude of their recent residuals. Although the presence of ARCH effects in the data does not invalidate standard inference, ignoring it may result in a loss of efficiency (Eviews 5, 2004). Two tests can be employed to test for heteroskedasticity although the testing procedure is quite similar. These are the ARCH LM and the white heteroskedasticity tests. In this study we utilise 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 Ragunathan, 2004). The test is a Langrage Multiplier (LM) test for heteroskedasticity and the procedure involves regressing the squared residuals on a constant and the lagged squared residuals up to lag q is estimated. The null hypothesis is of no ARCH effect in the data and two test statistics are reported, the F statistic and the Observed R-squared (which follows a χ^2distribution). If the test statistic is significant then there is evidence of ARCH effects in the data.

4.3.3 UNIVARIATE GENERALISED AUTOREGRESSIVE CONITIONAL HETEROSCEDASTICITY (GARCH) MODELS

The Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model was developed independently by Bollerslev (1986) and Taylor (1986). The GARCH model, which employs the maximum likelihood procedure, allows the conditional variance to be dependent upon previous own lags, so that the conditional variance equation is as follows:

$$h_t = \omega + \alpha\varepsilon^2_{t-1} + \beta h_{t-1} \ , \ \alpha + \beta < 1 \qquad [4.8]$$

This is a GARCH (1, 1) model where h_t is the conditional variance, ω is a constant, α is the coefficient of lagged squared residuals, ε^2_{t-1} is the lagged squared residual from the mean equation and β is the coefficient for the lagged GARCH component which is the lagged conditional variance. The condition given in [4.8] i.e. $\alpha + \beta < 1$ is necessary for stationarity of the GARCH model. As Brooks (2003) notes, there is no theoretical justification for a model whose summation of the lagged residual term and the lagged conditional variance term is more than one. The GARCH model is parsimonious and avoids over-fitting. As a result it is less likely to breach non-negativity constraints (Brooks 2003:453). Brooks (2003:453) further argues that a GARCH (1,1) model is usually sufficient to capture volatility clustering in the data, hence any higher order model of GARCH is not estimated in the academic finance literature.

If, after estimating the GARCH model, further tests suggest the presence of ARCH effect, then we explore the E-GARCH model. E-GARCH is an asymmetric model. Brooks (2004:469) suggests that equity returns exhibit asymmetric responses of volatility to positive and negative shocks which are attributed to leverage effects. Leverage effects is a situation whereby a fall in the value of a firm's stock causes the firm's debt to equity ratio to rise which leads ordinary shareholders to perceive their future cash flow stream as being relatively more risky. The Exponential GARCH method proposed by Nelson (1991) is specified with the following conditional variance equation:

$$\log(h_t) = \omega + \beta \log(h_{t-1}) + \gamma\left(\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right) + \alpha\left[\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}} - \sqrt{2/\pi}}\right], \qquad [4.9]$$

$\delta + \beta < 1$, $\gamma \neq 0$ if the impact is asymmetry and $\gamma < 0$ if leverage effect is present.

Where α and β are still interpreted as they are in the GARCH (1, 1) model and γ is the asymmetry coefficient. As evident from the conditions given under the equation, if $\gamma \neq 0$ and significant, then negative shocks imply a higher next period conditional variance than positive shocks of the same magnitude (i.e. asymmetric impacts). A leverage effect, which is a special case of asymmetric impacts, would exist if $\gamma < 0$ (Eviews, 2004:597).

The EGARCH model provides a number of advantages over the pure GARCH. Firstly, since the Log (h_t) is modelled, then even if the parameters are negative, h_t will be positive thus there is no need to artificially impose non-negativity constraints on the parameters. Secondly, asymmetries are allowed for since if the relationship between volatility and returns is negative, δ will be negative (Brooks, 2004:469).

The GJR GARCH will also be explored. Like the EGARCH model, this model captures asymmetry. However, the specification and interpretation of the model differ from the EGARCH. The GJR GARCH was proposed by Zakoian (1990) and Glosten, Jaganathan and Runkle (1993). This model is simply a re-specification of the GARCH (1, 1) model with an additional term to account for asymmetry as follows:

$$h_t^{\ 2} = \alpha_0 + \alpha_1 \varepsilon_t^{\ 2} + \beta h^2{}_{t-i} + \gamma \varepsilon^2{}_{t-1} I_{t-1}, \qquad [4.10]$$

where $I_{t-1} = 1$ *if* $\varepsilon_{t-1} < 0$
$= 0$ *if otherwise*

I is the asymmetry component and γ is the asymmetry coefficient. If leverage effects exist, then the coefficient of asymmetry coefficient will be positive and significant (i.e. $\gamma > 0$). The idea behind this is: good news ($\varepsilon_t > 0$) and bad news ($\varepsilon_t < 0$) will have different impacts on conditional variance. While good news will have an impact of α_1, bad news will have an impact of $\alpha_1 + \gamma$. Thus, if γ is significantly different from zero, then clearly the impact of good news is different from the impact of bad news on current volatility. If $\gamma > 0$ leverage effect exists in stock markets and if $\gamma \neq 0$ [20] then the impact of news is asymmetric (Eviews 5, 2004:587). The theoretical argument for the existence of leverage lies in the source and cost of capital. Bad news normally causes a decline in stock prices and this increase the firm's debt to equity ratio. As a result the risk of equity investments will increase, and as investors react to this increased risk, the volatility of stock prices will increase.

4.3.4 EXAMINING TRENDS IN VOLATILITY

Since volatility in stock market can affect financial stability (see Shikwambana, 2007), it is worth investigating its long term trend. In order to analyse the trend of volatility overtime, we regressed each of the conditional variance series against a constant and a time variable as follows:

$$h_t = \beta_1 + \beta_2 T \qquad [4.11]$$

Where h_t is the conditional variance in each market and T is the time in days. If β_1 is positive and significant then it implies that volatility increases over time, while a negative and significant β_1 would indicate that volatility decreases over time.

4.4.0 PROXIES, DATA AND IMPLICATION FOR TRADING SEQUENCE

Empirical studies on international linkages of equity markets employ different proxies depending on the objectives of the study and the econometric technique utilised. Studies that aim to analyse the possibility of long term gains from international diversification normally use closing-to-closing stock market indices for the respective stock markets (see Allen and McDonald, 1995). One reason why these studies utilise such a proxy is that it is normally level non-stationary, unlike return series which are level stationary. As mentioned earlier, level non-stationarity of series is one of the preconditions for the series to be applicable for cointegration analysis. On the other hand, studies that seek to establish whether return linkages exist between stock markets use stock market returns

[20] The difference between $\gamma > 0$ and $\gamma \neq 0$ is that in the former case the parameter, γ only takes positive value and such an instance would imply that there is evidence for both leverage and asymmetric effects. In the latter case γ 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, 2004:597).

as their proxies. Since return series are not readily available, they are computed from market indices series as follows:

$$y_t = (InP_t - InP_{t-1}) \times 100 \qquad [4.14]$$

Where y_t is current continuous compounded returns, P_t is the current closing stock price index and P_{t-1} is the previous day closing stock market index. Finally, studies that seek to investigate the extent of volatility transmission between stock markets utilise volatility series following any of the methods described above.

The dataset used in this analysis comprises the daily closing capital indices (P_{it}) for the seven stock markets for the period 30/12/1995 to 28/02/2007, totalling 3 125 observations. Following existing empirical literature, the indices used are in domestic currencies (see Koutmos, 1996; Darrat and Benkato, 2003; Tastan, 2005). Berben and Jansen (2005:835) argue that expressing returns in domestic currencies will ensure that true price developments as they are perceived in the financial press and by policy makers are reflected. The following indices were used for the respective stock markets: All Ordinaries index for Australia, Heng Teng index for the Chinese stock market, DAX index for Germany, the Nikkei 225 index for Japan, FSTE index for South Africa, the FTSE 100 index for United Kingdom and the Standard and Pool (S&P 500) for United States of America[21]. The choice of these indices has been motivated by the fact that they are the most recurring in empirical studies[22]. All the indices were obtained from the 2007 Financial DataStream of the Wall Street Journal, except for the FTSE, which was obtained from the JSE

There are a number of issues with regard to the choice of data frequency for financial markets research. Daily data is preferred to low frequency data as it captures the dynamic interactions that occur within a day, a property that cannot be captured by low frequency data. Financial markets in general, and the stock market in particular, react promptly as soon as new information becomes available – reaction can even be within hours, minutes or seconds. Thus, lower frequency data distorts such reactions. Korolyi and Stulz (1996:3) argue that "the daily data horizon is important for risk management purposes and for portfolio managers whenever dynamic hedging strategies are used." Moreover, from the point of view of policy makers concerned with financial stability,

[21] In this study, the following names are used to represent the various series: the Australian index (AUS), the Chinese index (CH), the Germany index (GR), the Japanese index (JPN), the SA index (SA), the UK index (UK) and the US index (US). The following notations were used for the returns series: AUS1, CH1, GR1, JPN1, SA1, UK1 and US1. For volatility series the following notations were used VOLAUS, VOLCH, VOLGR, VOLJPN, VOLSA, VOLUK and VOLUS.

[22] Some empirical studies use the Dow Jones index (e.g. Glezakos *et al.*, 2007) for the US stock market as it is the main index for the NYSE. However, this index has lost favour as the most representative index for the US stock market due to the fact that it is computed from only 30 big companies. Given the extensive size of the US stock market, the S&P 500 which is computed from 500 stocks is more appropriate. Besides the S&P 500 has become the most widely published in financial news (INVESTOPEDIA, 2007).

correlations and comovements at a high frequency are more relevant than correlations and comovements over long horizons (Berben and Jansen, 2005:835).

However, there are also problems with daily data. Firstly, there are distortions that may arise due to non-trading during holidays and noise trading. Glezakos *et al.*, (2007:28) suggests that a possible way to resolve the problem of non-trading is to calculate the relevant index by simulation for that particular day. Another possible way to resolve this problem is to eliminate all the non-traded days of each market across all markets. Such an approach was followed by Chowdhury (1994) and Chang *et al*., (2006). For this study, we preferred the latter since there is no guarantee that simulation will provide the index that could have resulted had the market been opened. Since our sample size is very large, this is not expected to have any effects on the empirical findings.

Another important concern that arises from the use of daily data is that financial markets in different continents operate at different times. Such lack of coincidence among international stock markets has important implications for interpretation of our results as well as the specification of cointegration and VAR models. For instance, the Japanese stock market trades before the JSE Securities Exchange opens, whilst the US stock exchange trades after the JSE. As noted by Isakov and Perignon (2000:6), this has two implications for this analysis. Firstly, an overlapping period will exist between the returns of the contemporaneous US (r_{USt}) and the lagged South African returns (r_{SAt-1}). Secondly there also exists an overlapping period between contemporaneous SA returns (r_{SAt}) and the lagged Japanese returns (r_{JPt-1}). This overlapping might result in the Granger causality[23] between r_{SAt-1} and r_{USt} on one side and between r_{SAt} and r_{JPt-1}on the other side to be upward biased. A possible solution to limit this problem as suggested by Hamao et al (1990) and Koutmas and Booth (1995) is to compute *open to close* returns. However, Isakov and Perignon (2000:7) express doubts that this could fully solve the problem of non-synchronicity of trading hours as it neglects significant periods of time when the market is closed, when information may arrive. They further argue that the opening prices are "subject to frequent microstructure problems". Nevertheless, a comparison of the results obtained from utilising *close to close* and *open to close* returns by Hamao *et al*., (1990) revealed that they give very close empirical results. For this reason our study uses the *close to close* data. Another approach is to lag the indices or returns of the market which trade behind the other in the VAR/VECM specification. In this study, the latter approach will be used in the VAR specification for the Johansen cointegration test as well as for the VECM. However, the same approach will not be used for the VAR for analysing returns

[23] The term Granger causality is used to distinguish between statistical causality which will be investigated here using the VAR and real causality.

and returns linkages. Here the trading sequence of the markets will only be used for orthogonolizing/ordering of the markets for impulse response and variance decomposition analysis.

4.4.0 CONCLUSION

In this chapter, we have chronologically set out the analytical framework which we will utilise in addressing the questions regarding the long run comovement, dynamic returns linkages and volatility transmission between the SA equity markets and the world equity markets which are being studied. Firstly the analytical framework for long run comovement, i.e. the Johansen cointegration approach and a stationarity test, were discussed. We then discussed the VAR model together with impulse response and variance decomposition and how these approaches will be used to analyse returns linkages among the stock markets. The analytical framework for examining volatility and volatility linkages among stock markets was then described. Here we discussed the univariate GARCH and its asymmetric extensions, how they are estimated (i.e. the mean equation) and how they are utilised in examining the nature of volatility in stock markets as well as generating the GARCH variance series which serve as a proxy for volatility. Also described is how a VAR framework to analyse the volatility transmission across equity markets. Lastly, we discussed the proxies and data used in this study, the issues arising from use of daily data and how the issue of different trading time zones will be dealt with in this study. Having set out the analytical framework, we now move on to apply them to the seven stock market indices and returns series with a view to achieve the objectives of this study as set out in Chapter 1.

CHAPTER FIVE:
ANALYSIS OF EMIPIRICAL RESULTS

5.0. INTRODUCTION

In Chapter 1, the following objectives were set: (i) examining the long-run comovement between the South African (SA) stock market and the world stock markets with a view to analysing the extent to which SA long-term investors can benefit from international portfolio diversification, (ii) examining the dynamic returns linkages between the SA and selected stock markets as well as the speed, magnitude and nature of these return linkages and whether there are any reverse influences i.e. from SA to these markets, (iii) examining the nature of volatility in each of the stock markets being studied as well as investigating the long-run trends of volatility, (iv) examining volatility linkages between the SA and the world stock markets as well as the magnitude and speed of volatility transmission from these world markets into the SA stock market and whether there is reverse transmission of volatility. Having reviewed the existing empirical literature, analysed the possibilities of linkages between the stock markets and set out the analytical framework, we now apply the analytical framework to address these objectives.

This chapter is divided into six main sections. Section 5.1 discusses the descriptive statistics and the simple correlations between the markets. Section 5.2 applies the Johansen cointegration technique to answer the question regarding the long run comovement of the stock markets. Section 5.3 uses VAR, impulse response and variance decomposition to analyse the return linkages between the stock markets. Volatility and volatility linkages are examined in section 5.4. Finally section 5.5 concludes the chapter.

5.1 DESCRIPTIVE STATISTICS AND SIMPLE CORRELATION TEST

Table 5.1 below provides the summary statistics, namely, sample means, maximums, minimums, medians, standard deviations, skewness, kurtosis and the Jarque-Bera tests with their p-values for the return series. Whilst it is clear that all the statistics show the characteristics common with most financial data, for instance non-normality in the form of fat tails, there are a number of noticeable differences, especially between developed and emerging stock markets. Firstly, returns in emerging stock markets are larger than those of their developed counterparts. More specifically, the smallest of the emerging stock markets (SA) has the largest unconditional average daily stock market return of around 0.026%. The returns for SA fluctuate between the minimum of -5,48% and a maximum of 4.38%. Among the emerging markets, Australia has the second highest average returns and China the third with unconditional average returns of 0.017% and 0.012% respectively.

Of the developed stock markets Germany has the highest unconditional average returns of around 0.020% with Japan having the lowest unconditional mean returns of around 0.003%. The US, which is the world's largest stock market, has unconditional mean returns of about 0.016% and its returns fluctuate between -3.08% and 2.42%. A common observation is that the emerging stock markets (China and SA) have more extreme values (i.e. the difference between the maximum and the minimum) for the daily returns compared to the developed stock markets. This could be an indication that volatility is much higher in emerging stock markets than in developed stock markets, which is well in line with most theoretical and empirical literature.

Surprisingly, contrary to the common findings that the unconditional standard deviation for emerging markets tends to be higher than in developed markets, indicating the existence of more risk in the former markets (see Tastan, 2005:6), the picture seems to be mixed in our case. As evident from the table, China, an emerging country, has the highest unconditional standard deviation of around 0.75%, whilst Australia has the lowest of about 0.36%. Quite surprisingly, the smallest emerging market of the sample, SA, has a standard deviation which is well below some of the world largest stock markets, i.e. Japan and Germany. This could be due to the fact that there has been a gradual improvement in investors' optimism since the 1994 democratisation. Returns of most of the stock markets under consideration are negatively skewed except for the Asian stock markets (China and Japan). All the stock markets under consideration have distributions with positive excess kurtosis and show evidence of fat tails. A distribution with a kurtosis value of more than 3 is described as leptokurtic relative to normal (Bala and Premaratne, 2003:5). This implies that the distribution of stock returns in all the stock markets tends to contain extreme values. Lastly, the Jarque-Bera (JB) statistic tests whether the series are normally distributed. As can be seen from the table, the JB indicates that the hypothesis of normality is rejected for all return series. This non-normality is also evident from the fatter tails of the kurtosis and negative and positive skewness. This is contrast to the market efficiency hypothesis.

TABLE 5.1: DESCRIPTIVE STATISTICS

	AUS1	CH1	GR1	JPN1	SA1	UK1	US1
Mean	0.017	0.013	0.019	0.003	0.026	0.011	0.016
Median	0.027	0.022	0.047	0.006	0.036	0.028	0.030
Maximum	2.634	7.491	3.801	3.325	4.383	3.366	2.421
Minimum	-4.119	-6.399	-4.498	-3.142	-5.484	-3.72	-3.089
Std. Dev.	0.358	0.750	0.704	0.641	0.589	0.502	0.499
Skewness	-0.967	0.235	-0.151	0.018	-0.496	-0.117	-0.048
Kurtosis	15.190	16.198	6.676	4.801	10.89	7.370	5.991
Jarque-Bera	1626.100	1860.500	1451.100	346.3000	6750.000	2043.000	955.100
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 5.2: CORRELATION MATRIX FOR RETURNS

	SA1	US1	UK1	CH1	AUS1	JPN1	GR1
SA1							
US1	0.281						
UK1	0.482	0.482					
CH1	0.473	0.189	0.392				
AUS1	0.469	0.170	0.348	0.526			
JPN1	0.326	0.150	0.307	0.439	0.448		
GR1	0.457	0.555	0.748	0.370	0.326	0.282	

Table 5.2 shows the pairwise correlation matrix and there is evidence of contemporaneous correlation among the markets. Correlation between all the markets is positive, which tends to indicate that there is a common trend/factor that is driving the markets in the same direction. This is adverse for international diversification since one condition for international diversification is that correlation between returns should be negative to ensure that some markets will go up if some go down (Narayan and Smyth, 2005:232). However, the other condition for international portfolio diversification (i.e. correlation among stock markets should be low) is satisfied. As is evident from Table 5.2, correlation between most of the stock markets returns (except for the case of the Chinese with the Australian stock markets, the German with the US stock markets and the UK and German markets) is low (i.e. less than 50%). The SA stock returns are mostly correlated to the UK, Chinese, Australian, German, Japanese, and US stock markets in descending order. This raises a question as to whether the UK is the market that has the strongest influence on SA returns. The correlation matrix can not provide any empirical answer to this question since correlation does not imply causality (Gujarati, 2005). Furthermore, correlation merely provides insight into short run market linkages, but fails to account for long term arbitrage activities in stock markets (Narayan and Smyth, 2005:233). We therefore need to infer this from other empirical tests.

5.2 LONG RUN COMOVEMENT OF THE STOCK MARKETS

5.2.1 TEST FOR STATIONARITY

As can be recalled from the previous chapter, the two formal were employed in this study are the ADF and the KPSS. Since graphical plots of the all index series[24] were trending, the tests were done using the ‘intercept and trend’ deterministic trend assumption. The appropriate lag length for the ADF test was selected using the Schwarz information criterion 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 shocks/information within 30 days. The KPSS was estimated using the Bartlett Kernel estimation method. The results of both tests are reported in Table 5.3 below.

[24] See Fig 3.3 Chapter 3.

TABLE 5.3: UNIT ROOT/STATIONARITY TEST (WITH INTERCEPT AND TREND)

SERIES	ADF		KPSS	
	Level	1st Difference	Level	1st Difference
AUS	-0.249	-51.672[a]	0.854	0.131[a]
CH	-1.715	-49.341[a]	0.425	0.079[a]
GR	-1.511	-50.586[a]	0.806	0.185[a]
JPN	-1.397	-51.853[a]	0.829	0.161[a]
SA	0.305	-50.449[a]	0.921	0.149[a]
UK	-1.907	-50.943[a]	0.833	0.162[a]
US	-1.915	-50.383[a]	0.893	0.145[a]

Notes: The MacKinnon (1996) (i.e. for ADF test) 1% critical value = -3.961629 and the KPSS (1992) 1% critical value = 0.216, thus [a] denotes the rejection of the hypothesis of a unit root/non-stationarity for both tests. The lag order for the series for the ADF was determined by the Schwarz information criterion and the spectral estimation method used for KPSS is Bartlett Kernel.

As noted earlier, the ADF tests the null hypothesis that the series have a unit root, while the KPSS tests the null hypothesis that the series are stationary. Thus, while in the former case rejection of a null hypothesis would mean that the series does not have a unit root (i.e. is stationary), in the latter case rejection of the null hypothesis implies that the series is non-stationary (i.e. has a unit root).

Results from both the ADF and the KPSS show that, given the significance level of 1%, all the index series are non-stationary at level. However, all the series become stationary when differenced once. This implies that all the series are integrated of order 1 i.e. they are all I (1). As mentioned in the preceding chapter, a linear combination of I (1) series could be I (0) if the series are cointegrated. We thus proceed to test for cointegration of the index series.

5.2.2 JOHANSEN COINTEGRATION ANALYSIS

As noted earlier our cointegration analysis follows Allen and McDonald (1995:37-41). We start by carrying out bivariate cointegration using both the Johansen (1988) and then the multivariate Johansen's cointegration approach.

5.2.2.1 BIVARIATE COINTEGRATION

The bivariate cointegration analysis was carried out with a view to tracing whether there is a pairwise long-run relationship between the SA equity market and each of the markets under study. This was done by first specifying a VAR with SA index and each of the indices and then testing for cointegration.

The Johansen cointegration analysis requires that appropriate lag order and deterministic trend assumption for the VAR order be specified. Hall (1991) emphasises the significance of choosing an appropriate lag arguing that a lag order that is too low will lead to problems with serial correlation whilst a too high one could potentially lead to small sample problems. Empirical studies have shown that the Johansen test statistics are sensitive to lag length chosen and suggestions have been that either test statistics for a range of lags will be reported or information criteria should be used in choosing an appropriate lag length (Allen and McDonald, 1995:37). Empirical experimentation with information has nevertheless shown that information criteria normally select conflicting VAR orders (see Takaendesa, 2005:98). In this study the information criteria approach was used. 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 market are considered one of the most informationally efficient markets. This is especially true in our case since the sample is comprised of stock markets which are among the 15 leading world stock markets. Results for the VAR lag orders selected by the information criteria are reported in Table 5.4.

TABLE 5.4: VAR LAG ORDER SELECTED BY INFORMATION CRITERIA

MODEL	SA(-1): AUS	SA(-1)-JPN	SA(-1):CH	SA: GR	SA: UK	SA: US(-1)
Information Criteria	VAR Lag	VAR Lag	VAR Lag	VAR Lag	VAR Lag	VAR Lag
LR	Lag 30	Lag 30	Lag 30	Lag 6	Lag 18	Lag 26
FPE	Lag 6	Lag 3	Lag 6	Lag 6	Lag 5	Lag 6
AIC	Lag 6	Lag 3	Lag 6	Lag 6	Lag 5	Lag 6
SIC	Lag 2	Lag 2	Lag 2	Lag 2	Lag 2	Lag 2
HQ	Lag 2	Lag 2	Lag 2	Lag 2	Lag 2	Lag 2

Note
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

As can be seen from Table 5.4 different information criteria selected conflicting lag orders. Since the information criteria give conflicting results, this study will not strictly base cointegration analysis on the selected lags. Rather, we start our cointegration test with the smallest selected VAR lag and then increase the lag until results with good residual diagnostic checking results are attained. As may be remembered from Chapter 4, this study only uses one diagnostic test: the serial correlation test.

The results from the pairwise Johansen cointegration are reported in Table 5.5. Also reported are the VAR lag order and the deterministic trend assumption used, the LM (χ^2) test for serial correlation test and the trace and eigenvalue statistics for each cointegration equation.

TABLE 5.5: BIVARIATE JOHANSEN COINTEGRATION RESULTS[25]

		SA-AUS	SA-JPN	SA-CH	SA-GR	SA-UK	SA-US
VAR Lag Length	Deterministic Assumption	4	4	4	4	4	4
	Test Statistics						
2	Trace	12.62(0.76)	12.77(0.76)	14.53(0.61)	9.04(0.96)	11.10(0.87)	14.92(0.58)
	Max	9.51(0.67)	11.41(0.47)	9.80(0.64)	6.10(0.960	7.46(0.86)	11.25(0.49)
LM $\chi^2(30)$		6.69(0.16)	8.65(0.07)	5.12(0.28)	5.36(0.25)	6.25(0.18)	14.01(0.01)
3	Trace		12.22(0.80)				
	Max		10.77(0.54)				
LM $\chi^2(30)$			3.76(0.44)				
5	Trace					10.39(0.91)	
	Max					7.05(0.90)	
LM $\chi^2(30)$						8.78(0.67)	
6	Trace	11.69(0.83)		13.11(0.73)	8.23(0.98)		14.38(0.63)
	Max	8.64(0.76)		9.02(0.72)	5.85(0.94)		11.25(0.49)
LM $\chi^2(30)$		3.23(0.53)		4.02(0.20)	5.86(0.21)		3.28(0.52)

Note:[a] indicates significance at 1% significance level, [b] Significant at 5% level, [c] Significant at10% level
Trace and Max denotes the trace statistic and the maximum eigenvalue respectively proposed by Johansen (1988, 1989). In each case the null hypothesis is no cointegrating vector versus 1 cointegrating vector.
P-values of each of the test statistics are given in ( )
LM (χ^2) is the test statistic for serial correlation in the VAR

As shown in Table 5.5, there is no evidence of pairwise cointegration between the SA equity market and any of the world stock markets being studied. The results are robust for the serial correlation diagnostic test. It is surprising that the SA equity market does not share a common long term trend with the world largest equity market, the US, the second largest, the Japanese or the fourth largest, the UK. The result is even more striking in the case of the UK, given that the London Stock Exchange provides capacity for dual-listing of some of the largest SA companies. Generally, the results are in contrast with the recent finance literature argument that due to increased globalisation, technological development and financial liberalisation, financial markets are expected to move together (Isakov and Perignon, 2000; Bala and Premaratne, 2004; Forbes and Chinn, 2004; Bonfiglioli and Favero, 2005). Our results are also in contrast with those of Allen and McDonald (1995) who established that Australia has a long run cointegrating relationship with some of the world's major equity markets. However, the differences in findings could be due to the fact that whilst the former used monthly data, this study uses daily data. The findings of this study are nevertheless in line with the common finding that there is little long run comovement between developing/emerging and developed stock markets (see for instance Chang *et al.*, 2006 and Alhassan, 2006).

There are three possible implications of our results. The first one is that the SA equity market is not integrated with the world equity markets considered in this study. The second implication

[25]For models where cointegration was not found, we do not report the results for the trace, maximum eigenvalue and the serial correlation as it will be impractical to report all the results for each of the lags attempted. Also to be noted is that for the cointegrating equation where cointegration was found, we experimented with a number different lags. Here we only report the lags that gave the best results.

flows from the first and it regards the possibility of gaining from international diversification. The non-existence of a cointegrating relationship between the SA and the considered stock markets implies that these markets offer potential for pairwise portfolio diversification for a SA portfolio manager. In analogy, the SA equity market also offers potential for pairwise portfolio diversification for the portfolio manager from the world equity markets being considered (Alhassan, 2006:11).

The third implication is with regard to the efficient market hypothesis (EMH) for international equity markets. This is because the existence of cointegration implies that causality must at least run from one direction (Allen and McDonald, 1995:39 and Aziakpono, 2006b). In this regard, if two stock markets indices move together in the long-run they will be violating the weak form efficiency as this would indicate that one stock market index can be predicted by the aid of the other stock market index. Stock prices from two distinct efficient equity markets can not be cointegrated (Chang *et al*., 2006:2277). Thus, the non-existence of cointegrating relationships between the SA and the world equity markets considered in this study implies that none of the markets help predict the long run path of the SA equity market price index. However, a note of caution should be sounded when interpreting the implication of cointegration for the EMH. As Masih and Masih (2001:14) note, non-existence of cointegrating relationship only invalidates "the existence of a long-run equilibrium tending relationship, but does not invalidate any short-run relationships which may arise due to profit-seeking opportunities in transaction." Thus, it is possible that the SA index may be predicted by at least one of the world stock market indices in the short run.

5.2.2.2 MULTIVARIATE COINTEGRATION

Thus far, a potential weakness with our results is that the assumption is that the South African investor will only hold bivariate portfolios. This is not plausible as international investors normally consider wide portfolios in making investment decisions. The theory of investment postulates that unsystematic risk exponentially decreases as the portfolio becomes wide (Howells and Bain, 2005:174). Thus, a typical equity internationally diversified portfolio should comprise stocks from more than two stock markets. One way to solve this is assuming that since the SA market does not have bivariate cointegration with any of the world equity markets being considered, a portfolio containing all the markets will be worthwhile. However, as Allen and MacDonald (1995:40) note this could lead to wrong inference about cointegration. The fact that a bivariate cointegration does not exist does not necessarily imply that a long run relationship will not exist for a portfolio containing more than two stock markets. To illustrate this point an approach of Allen and McDonald (1995) is partly followed. This approach involves forming portfolios that could be selected by a SA portfolio manager[26]. From the perspective of SA investors, a prior portfolio would be comprised of the biggest stock markets and then other smaller and emerging markets could be added. Thus, the following hypothetical portfolios; A; B; C; D were considered for multivariate cointegration using the Johansen (1988) and Johansen and Juselius (1990) techniques.

Portfolio A: With SA, GR, UK, US (-1)

Portfolio B: With SA (-1), UK (-1), GR (-1), JPN

Portfolio C: With SA (-1), UK (-1), GR (-1), CH

Portfolio D: With SA (-1), UK (-1), GR (-1), AUS

As in the bivariate cointegration scenario, our VAR lag length was selected using the information criteria, and then cointegration was carried out using the smallest lag until results with good serial correlation diagnostic properties were obtained. The results for the lag length selection are reported in Tables 5.6 and 5.7 respectively[27].

TABLE 5.6: VAR LAG ORDER SELECTED BY THE INFORMATION CRITERIA

INFORMATION CRITERIA	Portfolio A	Portfolio B	Portfolio C	Portfolio D
	VAR Lag	VAR Lag	VAR Lag	VAR Lag
LR	Lag 24	Lag 23	Lag 30	Lag 27
FPE	Lag 4	Lag 3	Lag 7	Lag 5
AIC	Lag 4	Lag 3	Lag 7	Lag 5
SIC	Lag 2	Lag 2	Lag 2	Lag 2
HQ	Lag 3	Lag 2	Lag 2	Lag 2

TABLE 5.7: MULTIVARIATE JOHANSEN COINTEGRATION RESULTS FOR THE 5 PORTFOLIOS

Null Hypothesis	Portfolio A	Portfolio B	Portfolio C	Portfolio D
Estimation Assumption	4	3	4	4
Lag length	3	3	5	5
r = 0: T	86.20(0.00)[a]	44.67(0.09)[c]	56.97(0.17)	78.01(0.00)[a]
: Max	47.80(0.00)[a]	29.93(0.03)[b]	33.32(0.04)[b]	41.90(0.00)[a]
r ≤ 1: T	38.40(0.09)[c]	14.74(0.80)	23.65(0.85)	36.11(0.10)[c]
: Max	26.40(0.04)[b]	8.37(0.88)	10.31(0.95)	24.35(0.08)[c]
r ≤ 2: T	12.01(0.81)	6.36(0.65)	13.35(0.71)	11.76(0.83)
: Max	7.50(0.89)	6.05(0.61)	7.92(0.83)	7.17(0.89)
r ≤ 3: T	4.51(0.67)	0.32(0.57)	5.43(0.54)	4.58(0.66)
: Max	4.51(0.67)	0.32(0.57)	5.43(0.54)	4.58(0.66)
$LM\chi^2(30)$	22.10(0.14)	21.11(0.17)	21.27(0.17)	17.59(0.35)

Note:[a] indicates significance at 1% significance level, [b] Significant at 5% level, [c] Significant at10% level
P-values of each of the test statistics are given in ( )
LM (χ^2) is the test statistic for serial correlation in the VAR

For Portfolios A and B a VAR lag length of 3 and for Portfolios C and D a VAR lag length of 5 produced serially uncorrelated residuals. Thus, cointegration analysis for these portfolios was

[26] Advice regarding forming these portfolios was given by one of the leading Asset managers in SA, the Foord Investec Fund. We wish to thank Professor Pierre Faure for his assistance in obtaining this information.

[27] The results for a summary of cointegrating vectors selected by the maximum likelihood statistics for each portfolio are reported in Table A2 in the appendix.

performed using these VAR lag lengths. Except for Portfolio B for which cointegration was performed using assumption 3, assumption 4 was used for all the other three portfolios[28]. All the cointegration results are robust for the serial correlation diagnostic test.

As shown in Table 5.7 and Table A2, there is evidence of two cointegrating vectors for portfolios A and D although the evidence is stronger in the former whose maximum likelihood statistics are significant at 1% and 5%. For portfolio B both the trace and maximum eigenvalue statistics suggest one cointegrating vector, whilst in the case of portfolio C only the maximum eigenvalue suggests one cointegrating vector. This is despite the fact that all markets included in these four portfolios showed no evidence of pairwise cointegration with the SA market.

In order to identify the true cointegrating vectors, VECM models normalised on SA were estimated for each of the portfolios[29]. The full results are reported in Table A3 in the Appendix. Reported here are the equations for the portfolios which showed evidence of error correction.

Portfolio A

$$SA_t = -3.167 - 1.463UK_t - 0.891GR_t + 2.746US_{t-1} \quad [5.1]$$

Portfolio C

$$SA_{t-1} = 18.363 - 10.550UK_{t-1} + 6.773GR_{t-1} - 1.82838CH_t \quad [5.2]$$

Portfolio D

$$SA_{t-1} = -1.124 + 2.899UK_{t-1} - 1.231GR_{t-1} - 2.643AUS_t \quad [5.3]$$

$$SA_{t-1} = 2.815 + 0.154\,UK_{t-1} + 0.406GR_{t-1} - 2.548AUS_t \quad [5.4]$$

As can be seen in Table A3 only one true cointegrating vector exists, for portfolio A, with the SA, UK and US equity markets showing evidence of error correction (i.e. with a negative and significant coefficients of adjustment). While the error correction coefficient for the US is negative and significant at 1%, the adjustments of SA and UK are also negative and significant at 5% and 10% respectively. The cointegrating equation for this vector is shown by [5.1]. For portfolio B, no significant and meaningful error correction was found. Thus, this portfolio has potential for gains. For portfolio C, SA, Germany and UK show evidence of negative and significant error correction at 1%, 1% and 10% levels respectively. Portfolio D has two cointegrating vectors, with SA and UK, both at 1% and Australia (at 10%) and Germany (at 1%) showing evidence of negative and significant error correction in the first and second vector respectively.

[28] This is because assumption 3 and not assumption 4 gave a cointegrating vector for portfolio B.
[29] The VECM normalising approach used here is in line with that employed by Allen and McDonald (1995).

Thus, despite the fact that no bivariate cointegration was found between SA and any of the world stock markets being studied, it has been shown that multivariate cointegration exists for some of the wider portfolios formed out of these markets. The existence of multivariate cointegration may be an indication that some of the markets being studied comove. For instance, some studies have found that developed stock markets share a common long-term trend[30]. Thus, it is possible that the cointegrating relationships that were established in multivariate cointegration analysis could just be picking up existing cointegrating vectors among the developed stock markets. Our analysis has however shown that the non-existence of bivariate cointegration does not necessarily invalidate the existence of multivariate cointegration. Nevertheless, despite the existence of multivariate cointegration, there is still great potential for portfolio diversification since cointegration is not strong in most of the cases and most of the coefficients of the long run equation for the cointegrating vectors are negative, meaning that these markets negatively comove with the SA markets – a condition that is necessary for portfolio diversification.

5.3.0 EXAMINING DYNAMIC RETURNS LINKAGES

Having established that the SA equity market moves with some of the world stock markets in the long run, we now test if this is also the case with return linkages between the SA and the world equity markets using the VAR model. An important step before the VAR analysis is to test for the stationarity of the series.

Graphical plots[31] of the returns series showed that they are neither trending nor have an intercept. Thus our unit root/stationarity tests use the 'no trend and no intercept' deterministic trend assumption. As in the previous case we use the ADF and the KPSS. The results are reported in Table 5.8.

TABLE 5.8: UNIT ROOT/STATIONARITY TEST FOR RETURNS SERIES

SERIES	ADF (at level)	KPSS (at level
AUS1	-51.49[a]	0.14[a]
CH1	-50.63[a]	0.08[a]
GR1	-51.13[a]	0.25[a]
JPN1	-51.19[a]	0.20[a]
SA1	-46.93[a]	0.17[a]
UK1	-51.78[a]	0.23[a]
US1	-50.48[a]	0.32[a]

Notes: The MacKinnon (1996) (i.e. for ADF test) 1 % critical value = -3.961629 and the KPSS (1992) 1% critical value = 0.216, thus [a] denotes the rejection of the hypothesis of a unit root/non-stationarity for both tests. The lag order for the series was determined by the Schwarz information criterion and the spectral estimation method is Bartlett Kernel for ADF and KPSS, respectively.

As can be seen from Table 5.8, results from both the ADF and the KPSS show that the returns series are stationary at level. Thus our VAR analysis will proceed with returns series.

[30] See for instance, Kasa, 1992; Allen and McDonald, 1995; Hassan and Naka, 1996.
[31] See Fig A3 Appendix.

5.3.1 VECTOR AUTOREGRESSIVE RESULTS

As with cointegration analysis, we lag the US returns since the US stock trades behind all the other markets. An important issue before estimating a VAR model is to determine the lag length. The choice of an appropriate lag length is an empirically challenging issue. While some authors advocate for use of economic theory for determining lag length (see Takaendesa, 2005), others argue for the use of information criteria. Furthermore, some scholars (e.g. Friedman and Shachmurove, 1997) have advocated for a higher lag order to ensure that an analysis will capture all the dynamics in the data. In line with this Eun and Shim (1989) utilised 15 lags. However, Bala and Premaratne (2003:18) argue that the use of information criteria will ensure that the model is kept parsimonious. Since there is no specific theory that guides the speed at which returns are transmitted from one stock market to another, this study utilises the information criteria. However, as noted earlier, different information criteria tend to select different lag length. Another problem is that some of the information criteria tend to be sensitive to the maximum lag length that is selected. In our experimentation, we established that the Akaike, Hannan-Queen and Schwarz Information Criteria are rarely prone to the latter problem. Moreover, they are widely employed in empirical studies. We thus utilise these three information criteria in our analysis.

These three information criteria suggested a lag order of 2. However, there is a possibility that the selected lag order may produce results that do not satisfy the estimation assumptions. Thus it is important to do some diagnostic checking to ensure that the final lag selected will give robust results with *white noise* residuals. The estimation therefore started with a VAR lag length of 2 and the lag length was subsequently increased until serial correlation was eliminated[32]. The results for the serial correlation diagnostic test are reported in Table 5.9[33].

TABLE5.9: LAG LENGTH SELECTION CRITERIA

Lag Length	LM (χ^2) Statistic	Probability
2	62.2721	0.0965
3	90.4473	0.0003
4	60.0602	0.0954
5	42.2997	0.7396

It is evident in Table 5.9 that lag 2, 3 and 4 show evidence of serial correlation. Serial correlation only disappears at lag 5. Thus we estimate our VAR using a lag order of 5 and the results for the significant lags are reported in Table 5.10.

[32] This criterion was also followed by Gallagher and Taylor (2002).

[33] It should be noted that the null hypothesis for serial correlation test is that the residuals are not serial correlated and thus rejection of the null implies that the residuals are serially correlated.

In analysing returns linkages using a VAR, it is important to distinguish between the influences of own-returns and those of returns from other markets. Since we are concerned with determining which of the stock markets has the greatest impact on SA returns, our discussion is mostly concerned with the influence of the other stock market returns on SA returns, rather than how all the markets influence each other.

The VAR results show significant multilateral returns interactions among the markets. Overall, the results show that historical returns, either own or from other stock markets, help explain SA current returns. This is in contrast to weak form efficiency. However, as noted earlier, although the VAR analysis is a useful tool to test for examining 'spillovers' and linkages between markets, the fact that there are so many coefficients and that coefficients of certain variables may change sign with different lags raises issues regarding interpretation. Additionally, the VAR estimates do not allow us to determine very much about the transmission of shocks across the system or the period of time that it takes these shocks to work through the system. Thus, weak exogeneity, impulse responses and variance decompositions are employed to examine the dynamic links between the markets and the transmission of the returns shocks.

TABLE 5.10: VAR RESULTS RETURNS LINKAGES

	AUS	JPN	CH	SA	GR	UK	US(-1)
AUS1(-1)	-0.151[a]	-0.156[a]	-0.127[b]		-0.140[b]	-0.095[b]	
AUS1(-2)				0.111[b]	0.109[b]	0.093[b]	
AUS1(-4)	-0.095[a]		-0.123[b]				
AUS1(-5)				-0.109[b]			
JPN1(-1)		-0.061[b]					
JPN1(-2)	-0.030[b]	-0.059[b]	-0.068[b]			-0.055[b]	
JPN1(-3)						0.038[b]	
CH1(-1)				-0.049[b]			
CH1(-3)	0.029[b]	-0.001[b]	0.057[b]	0.056[b]			
CH1(-5)				0.057[b]			
SA1(-1)	0.045[a]	0.049b		0.071[b]	0.046[b]	0.036[b]	0.040[b]
GR1(-1)	0.102[a]	0.174[a]	0.098[a]	0.072[b]		0.064[b]	0.312[a]
GR1(-2)					-0.051[b]		0.085[a]
GR1(-4)				0.094[a]			
UK1(-1)	0.131[a]	0.089[b]	0.279[a]	0.085[b]		-0.074[b]	0.201[a]
UK1(-2)	0.058[b]				0.088[b]		0.092[a]
US1(-2)	-0.037[b]			-0.077[b]	0.006[b]		-0.268[a]
US1(-3)				-0.067[b]			-0.113[a]
US1(-4)							-0.093[a]
US1(-5)		0.075[b]					
C	0.017[b]	-0.003[c]	0.012	0.026[b]	0.021[b]	0.011[b]	0.0104[a]

Note

- *[a] Significance at 1%, [b] significance at 5% level, [c] significance at 10% level.*

5.3.2. BLOCK EXOGENEITY

The weak exogeneity test results are reported in Table A4 in the appendix. As shown in Table A4, except for the Japanese and the UK equity markets, all the markets significantly influence the SA market returns at 1% level. The UK case is surprising given the dual listing agreement between the LSE and the JSE. As would be expected, the SA equity is the most endogenous since it does not influence any of the stock market returns except those of the US. On the other hand, the US stock market is the most exogenous. While it significantly influences returns of all the other markets, none of the stock markets influence its returns. This former result is in line with, amongst others Asharnapalli *et al*. (1995), Hassan and Naka (1996) and Masih and Masih (2001).

5.3.3 VARIANCE DECOMPOSITION

As has been mentioned earlier, the variance decomposition analysis seeks to address the question with regard to the proportion/percentage of the movements in the stock market returns that are due to its 'own' innovations, against those that are due to shocks to other stock markets. As noted earlier, the returns are ordered by trading sequence of the markets. Brooks and Tsolacos (1999) and Mills and Mills (1991) stress the importance of ordering variables in the decomposition arguing that it is as good as putting restrictions on the primitive form of the VAR. In line with Mills and Mills (1991) we adopt two orderings as follows[34]:

Order I: US, UK, GR, SA, CH, JPN, AUS

Order II:AUS, JPN, CH, SA, GR, UK, US

The variance decomposition results for the 5, 10, 20 steps ahead are reported in Table A5 (in the appendix). As evident from Table A5 the variance decomposition differs across the two orderings. For instance the influence of the US decreased in the order II, whilst the influence of Australia has increased in order II. However, there are certain common features that seem to be evident. Firstly, the US is the most exogenous in that its innovations tend to explain the variations in returns of all markets better than other innovations explain its returns. Secondly, SA and China seem to be the most open to international influence i.e. more than 30% of the variations in their returns are explained by foreign innovations in both cases, the highest of all markets. European markets on average seem to explain each other quite well. Nevertheless the main focus of this study is to examine which of the markets mostly influence SA. On average, for both orders the US followed by the Chinese influence SA returns most. It is surprising to note that innovations from the SA

[34]The ordering still follows the trading sequence. The first starts with the last to open and ends with the first to open, while the starts one starts with the first to open and ends with the last to open.

stock market explain variations in the European markets returns better than those from China and Japan. However, own innovations seem to be more important than cross innovations.

5.3.4 IMPULSE REPONSE

The impulse response function was estimated using the Cholesky approach and the results are reported in Figure A2. The orthogonalisation followed is in line with the approach used for variance decomposition. However, in analogy to the findings by Mills and Mills (1991:277), results from the two orderings were very similar. Thus we only reported the results for the normal trading sequence (i.e. Order II). Generally the response of SA returns to both own and to foreign markets innovations is positive. As would be expected, the response of SA returns to own innovations is the highest. It starts positive and high and it quickly declines to zero within the third day after which it becomes insignificantly negative and finally dies off within the seventh day. With regard to response from cross innovation, the SA returns seem to respond quickest to innovations in the Chinese, Japanese and the US stock markets, although response to innovations from the Asian markets is very insignificant. Response from the US innovations starts at zero in the first day, picks sharply and then sharply declines by the third day. This pattern of response to US market innovations is peculiar to all the markets. The response of the SA market to innovations from the European stock markets is also very insignificant. Response from the Australian innovations also starts significantly positive, sharply declines and almost dies off in day two, and it insignificantly continues and finally dies off within the sixth day. Response of other stock markets to SA innovations is also positive and fast although it seems insignificant for the case of the US and the Asian markets. Overall, consistent to informational efficiency, the response of all stock market returns to both own and cross innovations is quick i.e. it takes less than a week.

5.4 VOLATILITY AND VOLATILITY TRANSMISSION ACROSS THE MARKETS

Having established returns linkages between SA and the major world markets, we now investigate if this is also the case with volatility. As maybe recalled from Chapter 4, this will be done by first generating volatility/conditional variance series of each stock using an appropriate univariate volatility model and then analysing the volatility series using a VAR framework together with impulse response and variance decomposition.

In selecting our appropriate volatility model, we will also test for the hypothesis that more risk implies more returns by including the GARCH-in mean component in each of the volatility models.

5.4.1 THE MEAN-EQUATION FOR THE VOLATILITY MODELS

The mean equation [i.e. 4.7 in Chapter 4] was estimated for each of the stock markets. The results were then tested for ARCH effect to check whether volatility has been captured. As noted in Chapter 4, our mean equation is as follows:

$$y_t = \mu + \varepsilon_t \qquad [5.5]$$

Where y_t is returns for each of the stock markets, μ is a constant and ε_t is a white noisy error term. The mean equations were estimated and tested for ARCH effect. Reported in Table 5.11 are the DW statistics[35] from the mean equations and ARCH LM F-statistics.

TABLE 5.11: AUTOCORRELATION TEST FOR THE MEAN EQUATION

STOCK MARKET	DW STATISTIC	ARCH LM
AUS1	2.040	98.969[a]
CH1	2.002	241.200[a]
GR1	2.023	38.998[a]
JPN1	2.024	30.923[a]
SA1	1.993	200.930[a]
UK 1	2.047	105.542[a]
US1	1.999	78.562[a]

[a] implies significance at 1 % Level, [b] significance at 5% level and
[c] significance at 10% level

As is clear from Table 5.11, there is no significant evidence of autocorrelation for the mean equations of each of the stock markets. Another important thing that is clear from Table 5.11 is that all the stock markets show significant evidence of ARCH effect, implying that the mean equation did not adequately capture volatility. Having determined our mean equations, we now move on to determine the appropriate GARCH model and at the same time test for the hypothesis that high risk is associated with more returns.

5.4.2 DETERMINING THE APPROPRIATE GARCH MODEL AND TESTING FOR THE RISK PREMIUM HYPOTHESIS

The univariate GARCH (1, 1), EGARCH (1, 1, 1) and GJR GARCH (1, 1, 1) models were estimated with a variance-GARCH-M component to test the hypothesis that investors in a volatile market earn a premium. The results from our estimations are reported in Table 5.12. In the case of Germany, we estimated the models with a residual component 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.

[35]The critical DW is 2. If the test statistic is below 2 then there is evidence of positive autocorrelation and when it is above 2 there is evidence of negative autocorrelation.

The coefficient δ is the *Arch–in mean* coefficient and it measures the relationship between volatility and returns. For all the stock markets and in all models, this coefficient is statistically insignificant (except for the US, in the GARCH (1, 1) model, where the coefficient is only significant at 10% significance level). This means that for all the stock markets, except for the US, there is no significant risk premium in returns. This is in contrast with the behavioural finance suggestion that more risky stock markets are more rewarding than less risky ones.

In all the three models, the coefficient ϖ represents the intercept. Also in all the three models, the coefficients α_1 and β are the residual squared and variance squared coefficients, and α_2 is the second residual squared coefficient in the case of Germany. All the three coefficients are significant at 1% level for all the models, except in the case of Germany where α_1 is insignificant while α_2 is significant at 1%. For all the stock markets (except for Australia in the GJR model), the summation of the residual squared coefficient (α_1 or $\alpha_1 + \alpha_2$ in Germany's case) and the variance squared coefficient, β is very high (i.e. close to 1). This implies that volatility is persistent i.e. does not die off quickly. An important coefficient which is only peculiar to the EGARCH and the GJR GARCH is γ. As noted in Chapter 4, this is called a leverage/asymmetric coefficient and it tests the asymmetry hypothesis for volatility in the stock markets[36]. As is evident from Table 5.10, the leverage coefficient γ is negative and significant at 1% in the EGARCH model for all stock markets. This implies that bad news leads to more volatility than positive news of the same magnitude i.e. volatility is asymmetric and there is evidence of leverage effects in all the seven stock markets. The result is also confirmed by those from the GJR GARCH model, where the coefficient is positive and significant for all the stock markets.

Having interpreted the results from these estimated models, we now move on to identify the most appropriate model, from which volatility series will be generated. As hinted earlier, our selection criterion will be primarily based on summation of the residual and GARCH coefficients. As noted, for any GARCH model to be stationary, the following condition should hold: $\alpha + \beta < 1$. The ability of a model to capture ARCH effect is also considered in model selection.

For the EGARCH model, $\alpha + \beta > 1$ for all the stock markets. Furthermore, this model does not adequately capture volatility for Germany, since the F-LM statistic is significant at 1%. Thus, we drop the EGARCH model to open the way for comparison of the standard GARCH and the GJR GARCH. Both standard GARCH and GJR GARCH adequately capture volatility as is evident

[36] For interpretation of this hypothesis in the EGRACH and GJR GARCH model, see Section 4.33 in Chapter 4.

from insignificant F-LM statistics for all the stock markets. However for the GJR GARCH, $\alpha + \beta$ is smaller than $\alpha + \beta$ for the standard GARCH for all the markets. Moreover, since the results show that volatility is asymmetric and leverage effects are present in all the stock markets, the GJR GARCH will better capture volatility in all stock markets than the standard GARCH because the former has an asymmetry component. Thus, the GRJ GARCH is the most appropriate of the three models and we now use this model to generate our conditional variance/volatility series for each of the stock markets being studied.

TABLE 5.12: A COMPARISON OF THE GARCH MODELS

	GARCH (1,1)							EGARCH							GJR GARCH						
PARAMETER	AUS1	CH1	GR1	JPN1	SA1	UK 1	US1	AUS1	CH1	GR1	JPN1	SA1	UK1	US1	AUS1	CH1	GR1	JPN1	SA1	UK1	US1
δ	0.11	0.03	0.03	-0.02	0.06	0.07	0.12[c]	0.04	-0.02	0.03	-0.03	-0.01	0.06	0.09[c]	-0.01	0.02	0.01	-0.03	-0.01	0.03	0.04[c]
ϖ	0.01[a]	0.01[a]	0.01[a]	0.01[a]	0.01[a]	0.01[a]	0.01[a]	-0.20[a]	-0.13[a]	-0.17[a]	-0.16[a]	-0.22[a]	-0.12[a]	-0.14[a]	0.01[a]	0.01[a]	0.01[a]	0.01[a]	0.01[a]	0.01[a]	0.01[a]
α_1	0.12[a]	0.08[a]	0.02	0.08[a]	0.12[a]	0.09[a]	0.07[a]	0.12[a]	0.15[a]	0.04	0.16[a]	0.23[a]	0.13[a]	0.12[a]	-0.01[a]	0.03[a]	-0.01	0.03[a]	0.06[a]	0.01[a]	-0.01[a]
β	0.86[a]	0.92[a]	0.88[a]	0.91[a]	0.88[a]	0.91[a]	0.92[a]	0.95[a]	0.98[a]	0.97[a]	0.97[a]	0.97[a]	0.98[a]	0.97[a]	0.87[a]	0.92[a]	0.88[a]	0.90[a]	0.88[a]	0.93[a]	0.92[a]
α_2	N/A	N/A	0.09[a]	N/A	N/A	N/A	N/A	N/A	N/A	0.15[a]	N/A	N/A	N/A	N/A	N/A	N/A	0.06[a]	N/A	N/A	N/A	N/A
$\alpha_1 + \alpha_2 + \beta$	0.98	1.0	0.99	0.99	1.00	1.00	0.99	1.07	1.13	1.16	1.13	1.20	1.11	1.09	0.86	0.95	0.93	0.93	0.94	0.94	0.91
γ	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-0.14[a]	-0.06[a]	-0.07[a]	-0.07[a]	-0.08[a]	-0.10[a]	-0.12[a]	0.20[a]	0.10[a]	0.09[a]	0.09[a]	0.11[a]	0.12[a]	0.15[a]
F-LM	0.05	0.37	0.36	1.69	0.001	0.03	1.062	0.263	0.80	4.54[a]	1.18	0.01	0.07	1.03	0.03	1.21	0.95	1.956	0.464	0.09	4.64[a]
SIC	0.66	1.89	1.81	1.85	1.541	1.15	1.243	0.622	1.868	1.81	1.84	1.52	1.12	1.2	0.64	1.87	1.8	1.843	1.529	1.13	1.206
AIC	0.68	1.88	1.79	1.84	1.53	1.138	1.231	0.608	1.854	1.79	1.83	1.51	1.11	1.18	0.63	1.86	1.79	1.829	1.516	1.12	1.193

Note: [a, b, c] implies the coefficient is significant at 1%, 5% and 10% respectively.

δ - *GARCH-in-mean coefficient.*

ϖ - *The constant term for the various GARCH models.*

α *1 –* *The coefficient of the squared residual term.*

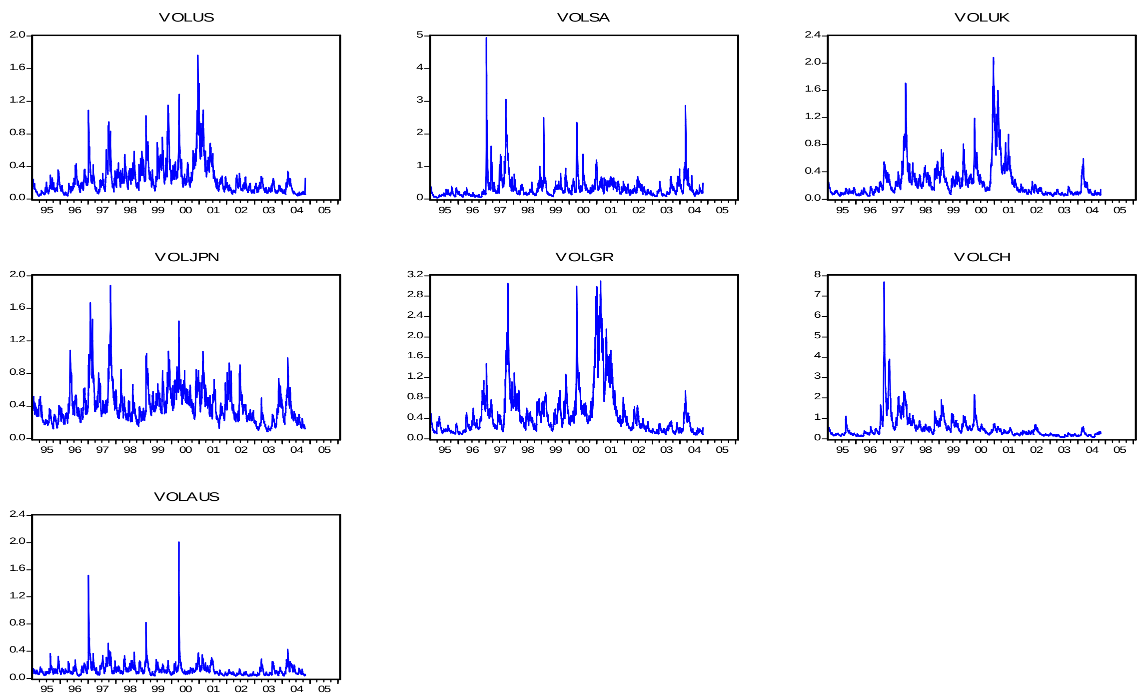
α *2 –* *The coefficient for the second squared residual term. This coefficient is only applicable in the case of Germany.*

$\alpha_1 + \alpha_2 + \beta$ *- Condition for stationarity of the GARCH model. Note that this is only the case for Germany, for the other markets, the condition is* $\alpha_1 + \beta$.

5.4.3 TRENDS IN VOLATILITY IN THE STOCK MARKETS

Before we examine the extent to which the equity markets are linked, we investigate the behaviour of volatility over time. The more volatile the stock market is, the more vulnerable it is to unsystematic risk. Since volatility is a measure of risk in the stock market, having the knowledge of its behaviour over time would be important both for investors and policy makers. For instance, if an investor is aware that volatility is likely to increase in future, then risk management and risk minimising (e.g. portfolio diversification and hedging using futures and options) can be made well in advance to avoid the danger of making huge losses. On the other hand too much volatility in capital markets will raise costs of capital, which could negatively impact on aggregate national investment expenditure. This is against government policies of promoting economic growth, which is pertinent especially for emerging and developing countries. Policy makers would therefore aim to formulate policies that will ensure the minimisation of volatility in capital markets in the long run. We start by showing graphical plots of volatility in the stock markets and then we will do empirical tests.

FIGURE 5.1: TRENDS IN VOLATILITY



As is evident from Figure 5.1, all the stock markets show evidence of excess volatility. Generally volatility for most of the stock markets except for the Japanese market seems to have decreased in recent years. Volatility for the Chinese and Australian equity markets seem to have significantly decreased since 2000. Similarly, volatility in the US seems to have decreased since late 2001. For the SA equity market, volatility seems to have decreased during the period 2001-2003, before suddenly increasing for the period 2003-2004 and since when it has stabilised. An important issue to consider is the behaviour of volatility during/after the 1997 Asian crisis and the 11 September 2001 US attacks. Volatility in SA, Japan, Germany, China, US, and UK seem to have increased during the Asian crisis. While reactions of emerging markets like China and SA can be attributed to emerging market contagion effects, reaction of developed markets could be due to the fact that investors shift their funds into developed markets if there is a crisis in emerging markets.

Volatility for the US, Germany and UK seem to have increased just after the September 11 attacks. The fact that only developed markets react could be an indication that only companies whose stocks were listed in US were affected and thus the non-reaction of emerging markets is reasonable since their companies rarely list on the US stock markets.

To formally investigate the long-term behaviour of volatility, the conditional variance series were regressed on time (see Equation 4.11 in Chapter 4). The results for the estimation are reported in Table 5.13.

TABLE 5.13: VOLATILITY OVER TIME

STOCK MARKET	β_1	β_2
VOLAUS	0.155(0.000)[a]	-0.000025(0.17)
VOLCH	0.817(0.000)[a]	-0.000009(0.94)
VOLGR	0.435(0.000)[a]	0.000016(0.89)
VOLJPN	0.448(0.000)[a]	-0.000089(0.57)
VOLSA	0.325(0.000)[a]	0.000004(0.96)
VOLUK	0.448(0.000)[a]	0.000010(0.85)
VOLUS	0.239(0.000)[a]	-0.000013(0.80)

[a] *implies significance at 1 % Level,* [b] *significance at 5% level and* [c] *significance at 10% level*
Reported in ( ) are the p-values

As is evident from Table 5.13, volatility in four stock markets – Australia, China, Japan and the US – is decreasing although not significantly. On the other hand volatility is insignificantly increasing over time for the SA, German and UK equity markets. Overall the results show that volatility in all the stock markets is relatively stable overtime. This implies these world stock markets have been relatively stable since mid-1995. This could be attributed to the fact that investors are becoming more confident in investing in equity markets and are not very responsive to crisis. This explanation is also confirmed by the fact that most of the markets under study, except China and Japan, did not respond very much to the Asian and Latin American crises[37]. Policy makers should welcome this finding and use it as a foundation for establishing policies to promote financial stability.

[37] See the graphical plots of the indices, Fig 3.1 in Chapter 3.

5.4.4 MODELLING VOLATILITY TRANSMISSION ACROSS THE MARKETS

5.4.4.1 SIMPLE CORRELATION OF VOLATILITY SERIES

As a preliminary step, the volatility series for the various markets were examined for correlation using the pairwise correlation matrix. The results for the correlation matrix are reported in Table 5.14. It is evident that, as in the case of returns, volatility for the stock markets is positively correlated. However, correlation in volatility seems to be more than that of returns. The SA equity market volatility is highly correlated with the Chinese, Australian, US and Japanese stock market volatilities, in descending order. This could be because of the emerging market contagion hypothesis was outlined earlier. Generally, volatility in the US is the most highly correlated with other markets, implying possibly that the US dominates volatility influence. Volatilities for two European stock markets are highly correlated. The fact that volatility is positive and high implies that potential gains from portfolio diversification are limited. Furthermore, it raises questions regarding the transmission of harmful contagion effects across the markets. However, since correlation does not imply causality, to provide more empirical content to the correlation results we extend our analysis regarding the possibility of volatility linkages using the multivariate VAR model.

TABLE 5.14: CORRELATION OF VOLATILITY

	VOLAUS	VOLCH	VOLGR	VOLJPN	VOLSA	VOLUK	VOLUS
VOLAUS							
VOLCH	0.666						
VOLGR	0.424	0.319					
VOLJPN	0.462	0.512	0.541				
VOLSA	0.743	0.783	0.438	0.507			
VOLUK	0.322	0.294	0.898	0.537	0.401		
VOLUS	0.536	0.473	0.763	0.547	0.536	0.794	

5.4.4.2 MULTIVARIATE VAR OF CONDITIONAL VARIANCES

In order to examine volatility transmission across stock markets, a VAR model was estimated for all the conditional variance series. As with the returns linkages, the lag length was determined by first taking the smallest lag selected by using the AIC and SIC information criteria and then increasing the lag length until the results from the VAR framework were serially uncorrelated. The two information criteria selected the 2^{nd} lag but the results were serially correlated. Only after increasing the VAR lag length to 25 was serial correlation eliminated. Thus, the VAR model was estimated using 25 lags. The results for the significant lags are presented in Table A7 in the appendix.

It is important to make a distinction between stock market volatility that is due to own shocks and that which is due to shocks from other markets. News and macroeconomic shocks that alter expected returns within a single stock market will generate volatility within that market (Shikwambana, 2007). On the other hand, common information and information spillovers provide a channel for the transmission of volatility shocks across the financial markets. Results from the VAR framework give volatility transmission from both within and across equity markets. Our interpretations start with volatility across equity markets and then own volatility.

As is evident from Table A7, there is significant own and cross volatility interaction among all seven stock markets. However, as noted earlier, the VAR is difficult to interpret if not complemented with the block exogeneity, impulse response and variance decomposition functions. Thus we turn to the results from these functions. As in the case of returns linkages, we orthogonolized our functions according to the trading sequence of the markets.

5.4.4.2 BLOCK EXOGENEITY

The results for Block Exogeneity are reported in Table A8 in the Appendix. Except for the Japanese and the Australian equity markets, all the other equity markets influence volatility in the SA equity market. As in the case of returns linkages, the US stock market is still the most exogenous of all, although in this case most of the stock markets, except for Australia and Japan, influence volatility in the US stock market. The German market seems to be the most endogenous, since its volatility is explained by all the other markets, yet it does not explain some of the other markets. Of importance to note is that volatility transmission between emerging markets (SA and China) is very significant, raising possibility of contagion effects during financial crises.

5.4.4.4 VARIANCE DECOMPOSITION

Table A9 (in the Appendix) reports the variance decomposition for the 5, 10 and 20 periods ahead. As in the case of returns linkages, we adopt a two-ordering orthogonolization. As is evident from Table A9, there is a marked difference in the results from the two orderings, with the US dominating in ordering I and Australia in ordering II. However, on average it is clear that the US is the most exogenous and dominant force. Again SA and China seem to be the most endogenous of all. Whilst the European stock markets (German and UK) seem to explain each other's volatility quite well, the situation is exactly opposite for the Asian stock markets (China and Japan). As hinted earlier, our main focus is which market's innovations explain variations in SA stock market volatility well. As is clearly evident from Table A6, the US innovations seems to be the most important for the 5 and 10 steps ahead volatility whilst the Chinese innovations is the most important for 20 period ahead volatility. Thus, the US and the Chinese are the most important sources of volatility for SA. The explanation for the US is the fact that it is the largest and most dominant market in the world. The strong influence from China could be due to the fact that investors in emerging markets view volatility in another emerging market with pessimism. These investors will then quickly respond by adjusting their portfolios and holdings, causing a prompter transmission of volatility than for developed countries. Overall, the results from variance decomposition show that shocks in one stock market explain volatility in others which justifies the existence of volatility transmission across equity markets.

5.4.4.3 IMPULSE RESPONSE

Figure A3 reports the response of each of the variances of one equity market to one standard deviation of volatility of other equity markets for ordering II[38]. Volatility in the SA equity market shows positive, significant and persistent response to own, Australia, China, Germany, and the US. The response to innovations from the US sharply increased in the first two days, before slowly decreasing continuously. The response of volatility of the SA to own and Australian innovations starts high and gradually decreases continuously. Response to the Chinese market innovations starts low in the first three days, then picks up and becomes relatively constant. Finally, response to innovations from Germany, Japan and UK seems to be insignificant. On the other hand, the extent to which other stock markets react to SA equity market innovations is also quite insignificant.

5.6.0 CONCLUSION

This chapter presented and discussed the estimations and results with regard to various issues concerning the manner in which the South African equity market is linked to the world equity markets. The first part of the chapter presented and discussed descriptive properties of the data and simple correlation in the data set. The basic picture shown by descriptive statistics is in line with the properties of financial data, notably non-normality, excess kurtosis and excess volatility (ARCH effect). The correlation matrix reveals positive although low pairwise correlation between the stock markets with exception of the European stock markets.

The long-run comovement of the stock market indices was then investigated using the bivariate and multivariate Johansen cointegration approach. While results from the bivariate cointegration showed that there is no pairwise cointegration between the SA and any of the stock markets, multivariate cointegration showed evidence of the existence of cointegrating relationship for some of the portfolios. Thereafter, returns linkages among the stock markets were examined using a

[38] Like with returns linkages, we estimated the impulse response functions for both Order I and Order II, but since the results were very similar, we only report those from Order II.

VAR, block exogeneity, impulse response and variance decomposition functions and significant returns linkages were established, with the US followed by China showing the most influence on SA returns. Next, volatility and volatility linkages among the stock markets were analysed. Evidence of leverage effects and asymmetry in volatility was also established, while except for the US, no evidence of risk premium in any of the stock markets was found. The long run trend of volatility for each stock market was examined and no significant increase or decrease was established for any of the markets. Finally, volatility transmission among the equity markets was examined, and significant volatility interactions were established with the US followed by China showing most influence on SA.

CHAPTER SIX:
SUMMARY OF FINDINGS, POLICY RECOMMENDATIONS AND AREAS FOR FUTHER RESEARCH

6.0 SUMMARY OF THE STUDY AND CONCLUSIONS

The study analysed the extent to which the South African equity market is integrated into world equity markets. This was done to assess the extent to which the SA equity market is integrated into global equity markets, with a view to giving policy recommendations and investment advice to South African investors. The purpose of the study was to address four main issues, namely: whether there is a long-run relationship between the SA equity market and world stock markets, whether there are any returns linkages between the SA market and world markets, whether there are any volatility linkages between the SA market and world markets, and examining the nature of returns and volatility linkages between the SA market and world equity market. The ultimate goal was to identify the equity market(s) that has the strongest influence on the SA equity market and the markets that offer potential for portfolio diversification for SA portfolio managers.

The first step in our study was to review the exiting relevant literature. Here we outlined the reasons for understanding the linkages of stock markets, and these were broadly classified into portfolio diversification, regulatory policy, monetary policy and stock market efficiency. Theoretical literature on the nature of linkages among financial markets and its implications for empirical studies were then reviewed. After this the empirical literature for developed, emerging and African stock market was reviewed. The basic trend in the empirical literature was that whilst early studies established that equity markets were less integrated, recent literature found increased interactions among international stock markets. Secondly, the literature documents strong comovement among developed equity markets and weak comovement among emerging and developing equity markets. In Chapter 3, we compared the stock markets being studied with a view to examining if there is any evidence/trends/picture that could suggest that markets move together. Comparison was with regard to size, liquidity, trading sequence and behaviour of stock market indices.

In order to address our objectives, three empirical analyses were carried out. Firstly the long run comovement of the stock markets was examined using the Johansen Cointegration approach. Prior to application of the Johansen Cointegration, we first tested for the stationarity of our series using the ADF and KPSS. It was established that all the series were stationary at first difference (i.e. they were *I(1)*) – a property that is necessary for Cointegration analysis. Bivariate Johansen Cointegration analysis was then used to examine whether there was pairwise long run comovement between the SA equity market and any of the world stock markets. No cointegrating vectors were found, implying that pairwise portfolio diversification is potentially worthwhile for SA investors. Following the finance proposition that ‘portfolio diversification is fruitful if more markets are added into the portfolio’, four hypothetical portfolios from the perspective of SA investors were formed and tested in a multivariate cointegration using the Johansen (1988, 1990) approaches. Cointegrating vectors were found for three of the portfolios. The VECM was estimated for these portfolios and except for the US, UK and Germany, evidence of error correction was weak. Thus, the implication for these findings is that the SA market is weakly integrated into the global equity markets and as such long term diversification is worthwhile for SA portfolio managers.

The next step in our empirical analysis was to examine the extent of returns linkages among the stock markets. Here the VAR framework, along with the block exogeneity, impulse response and variance decomposition functions, were estimated. Results from the VAR framework established that there are significant linkages of returns among the equity market. Results from block exogeneity showed that except for the Japanese and the UK equity markets, all the markets significantly influence SA market returns. The US was found to be the most exogenous, whilst SA was found to be the most endogenous. Furthermore, the response of SA to innovations from other markets was examined and responses to innovations from the US, Japan and China were the fastest. It was also established that the US has the dominant influence on SA returns followed by China and the other markets are not very important. However, own innovations were found to be more important than cross innovations. Overall, VAR findings seem to confirm the cointegration results that the SA stock market is not very well integrated into the global equity markets except for the US, which in any case is a dominant market that influences most markets.

After establishing the nature of returns linkages among the markets, we moved on to examine if this was also the case with volatility. Here we started by analysing volatility in each of the stock markets using GARCH (1, 1), EGARCH, and GJR GARCH and we found that volatility is persistent and asymmetric. Furthermore, the hypothesis that investors earn a premium in more volatile markets was investigated using GARCH-in mean model, and it was found that except for the US stock market there was no significant evidence of risk premium. The three models (GARCH (1, 1), EGARCH and GJR GARCH) were compared and GJR GARCH was found to be the best. Based on the GJR GARCH, conditional variance series were generated and used as a proxy for volatility. The behaviour of volatility overtime was also investigated and no significant trend in volatility was found for any of the stock markets.

The conditional variance series were then analysed using the VAR framework, block exogeneity, impulse response and variance decomposition. Results from block exogeneity showed that except for the Japanese and the Australian equity markets, all the other equity markets influence volatility in the SA equity market. Again, the US was found to be the most exogenous. Most of the variations in SA volatility seem to be explained by innovations from other stock markets, especially from the US and China. Response of SA volatility to other markets' innovations was found to be significantly positive and persistent, except for the response to innovations from UK, Germany and Japan, which was insignificant. On the other hand, the responses of other stock markets to SA equity market innovations were also quite insignificant.

Overall, the results from this study show that the SA equity market is not well integrated into most of the global equity markets considered, both in the short and long run. Thus, there is potential for gains from international portfolio diversification. However, there seem to be close volatility linkages between the SA and the stock markets considered in this study and this raises a concern of financial instability through transmission of harmful volatility. Block exogeneity results generally show that the US dominates both returns and volatility influence, not only in SA, but for all equity markets. Variance decomposition results show that of all the markets considered, the US explains most of the variations in SA returns and volatility. Impulse response results show that while the SA equity market returns respond promptly to innovations from the US, China and global equity markets, its volatility response is quite persistent.

6.1 POLICY AND INVESTMENT IMPLICATIONS

The findings of this study have important implications for policy and investment strategies. Firstly, the fact that the South African equity market is weakly integrated into the world stock markets considered implies that long term portfolio diversification may be worthwhile for SA portfolio managers. Thus, investors can exploit this to construct potentially risk-averting or profit maximising portfolios. For instance a portfolio comprising SA, UK, German and Japan could be worthwhile.

Nevertheless, the fact that the SA equity market is not well integrated into the world equity market should be of concern for policy makers. This is because more integration of world equity markets will ensure reduction of cost of capital (Kearney and Lucey, 2004:577). However, policy makers could capitalise on the fact that the SA stock market offers greater potential for portfolio diversification to attract foreign investors. We advocate that more openness and more relaxation of any implicit foreign currency control could be of importance to achieve this end.

Secondly, the fact that volatility from other stock markets is quickly transmitted into the SA stock market should be of concern for policy makers. This is because volatility affects financial stability. Volatility transmission from the world stock markets to the SA market could be harmful during times of crises. A crisis from one of the considered stock markets (particularly US and China) may be transmitted to the SA market and, given the fact that the SA market quickly absorbs volatility from other the markets, the situation could even be more worrying. This situation is referred to as the 'contagion effect' and it has been widely established in many emerging markets during the Latin American and Asian late 1990s crises. If such harmful volatility is transmitted into the SA equity, it could in turn be transmitted into other domestic markets (e.g. the money market and bond market) since it has been established that there are volatility linkages within domestic SA financial markets (see Chinzara *et al.*, 2007 and Shikwambana, 2007). This will threaten financial stability. Therefore, although financial markets should be opened, policy makers should to keep a 'watchful eye' on the behaviour of volatility in other emerging and developed markets and make sure that harmful volatility is proactively stemmed before it reaches the SA markets.

A further recommendation is with regard to monetary policy. In Chapter 2, section 2.1.3, we highlighted the importance of stock price volatility, bubbles and bursts on monetary policy. Since stocks form part of the wealth of consumers, increases in stock prices could lead to increases in consumption expenditure and in turn aggregate expenditure. This will in turn create inflationary pressures and compel the central bank to raise the repo rate. Thus, if a stock market is excessively volatile, the repo rate and hence interest rates could also be volatile and this could cause undesirable impacts on other macroeconomic variables e.g. investment and economic growth. Thus volatility in stock markets needs to be monitored and since this paper has established that there are both positive and negative transmission of volatility from developed and other emerging markets into the SA equity markets, there is need to watch developments in these markets so that appropriate policy responses can be made.

From this study, it is has been found that shocks from the Chinese and US stock markets should be of primary concern for variations in SA returns and volatility. Therefore, developments in these markets need to be closely watched both by policy makers and portfolio managers. However, this does not necessarily mean developments in other markets should be completely ignored.

6.2 AREAS FOR FURTHER RESEACH

While this study has used univariate GARCH and VAR models to analyse volatility and volatility linkages, an emerging trend in recent studies of linkages of financial markets is to use Multivariate GARCH model. We did not explore this model because the available software could not estimate it. Nevertheless, the methodology used managed to address our research questions.

Thus, further research in this area could employ the multivariate GARCH model and compare the results with ours. For the sake of comparison, different data frequencies could also be employed. Finally, this study has focused on one financial market and it is recommended that similar studies should be undertaken for the money, bond and foreign exchange markets so as to complement the current study in the quest for ways to improve financial stability and investment opportunities in the financial markets.

APPENDIX

MULTIVARIATE JOHANSEN COINTEGRATION TEST

Table A1: Serial Correlation Tests

Portfolio A:

VAR Residual Serial Correlation LM Tests		
H0: no serial correlation at lag order h		
Date: 06/18/07 Time: 16:54		
Sample: 1/06/1995 1/03/2007		
Included observations: 2555		
Lags	LM-Stat	Prob
1	13.94932	0.6025
2	27.37360	0.0375
3	22.09747	0.1401
4	19.49328	0.2439
5	21.17752	0.1718
6	31.34356	0.0122
7	23.37192	0.1041
8	24.76922	0.0740
9	14.21649	0.5826
10	26.17142	0.0517
11	40.73436	0.0006
12	15.73531	0.4716
13	17.74282	0.3392
14	19.52920	0.2422
15	19.62247	0.2377
16	17.05895	0.3818
17	37.45875	0.0018
18	44.52493	0.0002
19	6.748800	0.9778
20	15.45730	0.4914
21	17.83661	0.3336
22	24.83268	0.0728
23	32.50207	0.0086
24	13.15426	0.6614
25	23.53797	0.1001
26	11.02739	0.8078
27	11.14743	0.8003
28	15.57522	0.4830
29	15.97490	0.4547
30	26.26410	0.0504
Probs from chi-square with 16 df.		

<u>Portfolio B</u>

VAR Residual Serial Correlation LM Tests		
H0: no serial correlation at lag order h		
Date: 06/18/07 Time: 16:56		
Sample: 1/06/1995 1/03/2007		
Included observations: 2555		
Lags	LM-Stat	Prob
1	39.18517	0.0010
2	32.64510	0.0082
3	21.10729	0.1744
4	13.61408	0.6274
5	18.23977	0.3100
6	27.77072	0.0337
7	13.76175	0.6165
8	27.59363	0.0353
9	15.11471	0.5163
10	32.24671	0.0093
11	34.39910	0.0048
12	16.08643	0.4469
13	19.97242	0.2215
14	18.61290	0.2892
15	21.53000	0.1590
16	14.20646	0.5833
17	37.25671	0.0019
18	24.65856	0.0761
19	22.48658	0.1282
20	11.99622	0.7442
21	18.73072	0.2829
22	29.03711	0.0237
23	17.11898	0.3779
24	15.07070	0.5195
25	18.86699	0.2756
26	17.10672	0.3787
27	9.436527	0.8944
28	13.87112	0.6083
29	23.30522	0.1058
30	23.63416	0.0978
Probs from chi-square with 16 df.		

Portfolio C

VAR Residual Serial Correlation LM Tests		
H0: no serial correlation at lag order h		
Date: 06/18/07 Time: 16:58		
Sample: 1/06/1995 1/03/2007		
Included observations: 2555		
Lags	LM-Stat	Prob
1	40.44920	0.0007
2	40.09343	0.0008
3	32.45193	0.0087
4	40.20718	0.0007
5	21.27174	0.1683
6	41.80485	0.0004
7	18.58076	0.2910
8	23.15535	0.1096
9	30.36754	0.0162
10	16.95487	0.3885
11	22.42122	0.1301
12	20.90396	0.1822
13	24.92148	0.0712
14	18.41837	0.3000
15	22.58121	0.1254
16	23.38932	0.1037
17	32.57015	0.0084
18	22.64158	0.1237
19	11.37247	0.7859
20	17.97421	0.3254
21	11.79045	0.7583
22	25.12003	0.0677
23	29.29242	0.0220
24	28.69204	0.0261
25	13.52552	0.6340
26	14.28699	0.5773
27	9.951985	0.8691
28	13.40729	0.6428
29	22.47448	0.1285
30	38.12790	0.0015
Probs from chi-square with 16 df.		

Portfolio D

VAR Residual Serial Correlation LM Tests		
H0: no serial correlation at lag order h		
Date: 06/18/07 Time: 17:03		
Sample: 1/06/1995 1/03/2007		
Included observations: 2555		
Lags	LM-Stat	Prob
1	24.01207	0.0892
2	28.21523	0.0298
3	35.96403	0.0029
4	26.73926	0.0445
5	21.61815	0.1560
6	29.28867	0.0221
7	27.24801	0.0388
8	31.55888	0.0114
9	10.95095	0.8125
10	30.25761	0.0167
11	24.46932	0.0797
12	13.86341	0.6089
13	20.04248	0.2183
14	15.26463	0.5053
15	31.19854	0.0127
16	8.945080	0.9157
17	27.85174	0.0329
18	29.76906	0.0192
19	3.799030	0.9992
20	13.67496	0.6229
21	11.00445	0.8092
22	29.24336	0.0223
23	17.20397	0.3725
24	19.64313	0.2367
25	12.09679	0.7373
26	26.85421	0.0431
27	16.64380	0.4090
28	7.238458	0.9684
29	21.10393	0.1746
30	22.90375	0.1163
Probs from chi-square with 16 df.		

TABLE A2: SUMMARY OF NO OF COINTEGRATING VECTORS SUGGESTED BY THE TRACE AND MAXIMUM EIGENVALUE STATISTICS

Portfolio A

Date: 06/18/07 Time: 16:10					
Sample: 1/06/1995 1/03/2007					
Included observations: 2556					
Series: LSA LGR LUK LUS(-1)					
Lags interval: 1 to 3					
Selected (0.05 level*) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	0	0	0	1	1
Max-Eig	0	0	0	2	2

Portfolio B

Date: 06/18/07 Time: 16:20					
Sample: 1/06/1995 1/03/2007					
Included observations: 2556					
Series: LSA(-1) LGR(-1) LUK(-1) LJPN					
Lags interval: 1 to 3					
Selected (0.05 level*) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	0	0	0	0	1
Max-Eig	0	1	1	0	0

Portfolio C

Date: 06/18/07 Time: 16:43					
Sample: 1/06/1995 1/03/2007					
Included observations: 2554					
Series: LSA(-1) LGR(-1) LUK(-1) LCH					
Lags interval: 1 to 5					
Selected (0.05 level*) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	0	0	0	0	0
Max-Eig	0	1	1	1	1

Portfolio D

Date: 06/18/07 Time: 16:33			

Sample: 1/06/1995 1/03/2007					
Included observations: 2554					
Series: LSA(-1) LGR(-1) LUK(-1) LAUS					
Lags interval: 1 to 5					
Selected (0.05 level*) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	1	2	1	1	1
Max-Eig	1	2	2	1	2

TABLE: A3: VECTOR ERROR CORRECTION MODEL RESULTS

Portfolio A

Cointegrating Equation 1

Vector Error Correction Estimates				
Date: 06/18/07 Time: 18:30				
Sample (adjusted): 1/13/1995 10/29/2004				
Included observations: 2556 after adjustments				
Standard errors in ( ) & t-statistics in [ ]				
Cointegration Restrictions:				
B(1,1)=1				
B(2,1)=0				
Convergence achieved after 13 iterations.				
Not all cointegrating vectors are identified				
Restrictions are not binding (LR test not available)				
Cointegrating Eq:	CointEq1	CointEq2		
LSA(-1)	1	0		
LUK(-1)	-1.463083	3.510533		
LGR(-1)	-0.891081	-2.002104		
LUS(-2)	2.746363	-0.122773		
0.001754	-0.000324	6.57E-05		
C	-3.166666	-5.413812		
Error Correction:	D(LSA)	D(LUK)	D(LGR)	D(LUS(-1))
CointEq1	-0.00676	-0.003902	-0.001081	-0.01033
	-0.00234	-0.00201	-0.00283	-0.00159
	[-2.88487]	[-1.94033]	[-0.38235]	[-6.48010]

Cointegrating Equation 2

Vector Error Correction Estimates				

Date: 06/18/07 Time: 18:25				
Sample (adjusted): 1/13/1995 10/29/2004				
Included observations: 2556 after adjustments				
Standard errors in ( ) & t-statistics in [ ]				
Cointegration Restrictions:				
B(1,1)=0				
B(2,1)=1				
Convergence achieved after 1 iterations.				
Not all cointegrating vectors are identified				
LR test for binding restrictions (rank = 2):				
Chi-square(6)	0			
Probability	1			
Cointegrating Eq:	CointEq1	CointEq2		
LSA(-1)	0	1		
LUK(-1)	5.05E-12	-0.670823		
LGR(-1)	-2.88E-12	-1.342918		
LUS(-2)	-1.77E-13	2.718665		
0.001754386	9.46E-17	-0.000309		
C	-7.80E-12	-4.388483		
Error Correction:	D(LSA)	D(LUK)	D(LGR)	D(LUS(-1))
CointEq1	5.36E+09	2.25E+09	5.81E+09	3.95E+09
	-1.30E+09	-1.10E+09	-1.60E+09	-9.10E+08
	[4.00838]	[1.96422]	[3.60326]	[4.34461]

Portfolio B

Cointegrating Equation 1

Vector Error Correction Estimates				
Date: 06/18/07 Time: 17:58				
Sample (adjusted): 1/13/1995 10/29/2004				
Included observations: 2556 after adjustments				
Standard errors in ( ) & t-statistics in [ ]				
Cointegration Restrictions:				
B(1,1)=1				
Convergence achieved after 1 iterations.				
Restrictions identify all cointegrating vectors				
Restrictions are not binding (LR test not available)				
Cointegrating Eq:	CointEq1			
LSA(-2)	1.0000			
LUK(-2)	15.03851			
	-2.71463			
	[5.53979]			
LGR(-2)	-8.7946			
	-1.52199			
	[-5.77834]			
LJPN(-1)	-0.98561			
	-0.53464			
	[-1.84350]			
C	-23.4657			
Error Correction:	D(LSA(-1))	D(LUK(-1))	D(LGR(-1))	D(LJPN)
CointEq1	0.00082	-4.96E-05	0.001382	0.001312
	-0.00038	-0.00033	-0.00046	-0.00044
	[2.1463]	[-0.1509]	[2.97368]	[2.9855]

Portfolio C

Cointegrating Equation 1

Vector Error Correction Estimates				
Date: 06/18/07 Time: 18:12				
Sample (adjusted): 1/17/1995 10/29/2004				
Included observations: 2554 after adjustments				
Standard errors in ( ) & t-statistics in [ ]				
Cointegration Restrictions:				
B(1,1)=1				
Convergence achieved after 1 iterations.				
Restrictions identify all cointegrating vectors				
Restrictions are not binding (LR test not available)				
Cointegrating Eq:	CointEq1			
LSA(-2)	1			
LUK(-2)	-10.5503			
	-2.11962			
	[-4.97747]			
LGR(-2)	6.773325			
	-1.27089			
	[5.32960]			
LCH(-1)	-1.82838			
	-0.57831			
	[-3.16159]			
0.001754	-0.00033			
	-7.40E-05			
	[-4.52928]			
C	18.36387			
Error Correction:	D(LSA(-1))	D(LUK(-1))	D(LGR(-1))	D(LCH)
CointEq1	-0.00157	-0.00075	-0.0025	-0.00095
	-0.00043	-0.00038	-0.00054	-0.00062
	[-3.69762]	[-1.98799]	[-4.66392]	[-1.2333]

Portfolio D

Cointegrating Equation 1

Vector Error Correction Estimates				
Date: 06/18/07 Time: 18:16				
Sample (adjusted): 1/17/1995 10/29/2004				
Included observations: 2554 after adjustments				
Standard errors in ( ) & t-statistics in [ ]				
Cointegration Restrictions:				
B(1,1)=1				
B(2,1)=0				
Convergence achieved after 11 iterations.				
Not all cointegrating vectors are identified				
Restrictions are not binding (LR test not available)				
Cointegrating Eq:	CointEq1	CointEq2		
LSA(-2)	1.00000	0.00000		
LUK(-2)	2.89897	2.169975		
LGR(-2)	-1.230861	-1.294299		
LAUS(-1)	-2.643149	-0.075138		
0.0017544	0.000155	4.68E-05		
C	-1.124245	-3.114498		
Error Correction:	D(LSA(-1))	D(LUK(-1))	D(LGR(-1))	D(LAUS)
CointEq1	-0.008986	-0.008054	0.002043	0.000825
	-0.00279	-0.0025	-0.00355	-0.00193
	[-3.22152]	[-3.21916]	[0.57482]	[0.4267]

Cointegrating Equation 2

Vector Error Correction Estimates				
Date: 06/18/07 Time: 18:21				
Sample (adjusted): 1/17/1995 10/29/2004				
Included observations: 2554 after adjustments				
Standard errors in ( ) & t-statistics in [ ]				
Cointegration Restrictions:				
B(1,1)=0				
B(2,1)=1				
Convergence achieved after 1 iterations				
Not all cointegrating vectors are identified				
LR test for binding restrictions (rank = 2):				
Chi-square(3)	0			
Probability	1			
Cointegrating Eq:	CointEq1	CointEq2		
LSA(-2)	0	1		
LUK(-2)	-3.96E-12	0.154107		
LGR(-2)	2.36E-12	0.406326		
LAUS(-1)	1.37E-13	-2.548087		
0.001754	-8.54E-17	9.56E-05		
C	5.68E-12	2.81534		
Error Correction:	D(LSA(-1))	D(LUK(-1))	D(LGR(-1))	D(LAUS)
CointEq1	-1.48E+09	5.74E+08	-8.20E+09	-1.87E+09
	-1.60E+09	-1.40E+09	-2.00E+09	-1.10E+09
	[-0.9214]	[0.3997]	[-4.0159]	[-1.6866]

RETURNS LINKAGES RESULTS

FIGURE A1: GRAPHICAL PLOTS OF RETURNS SERIES

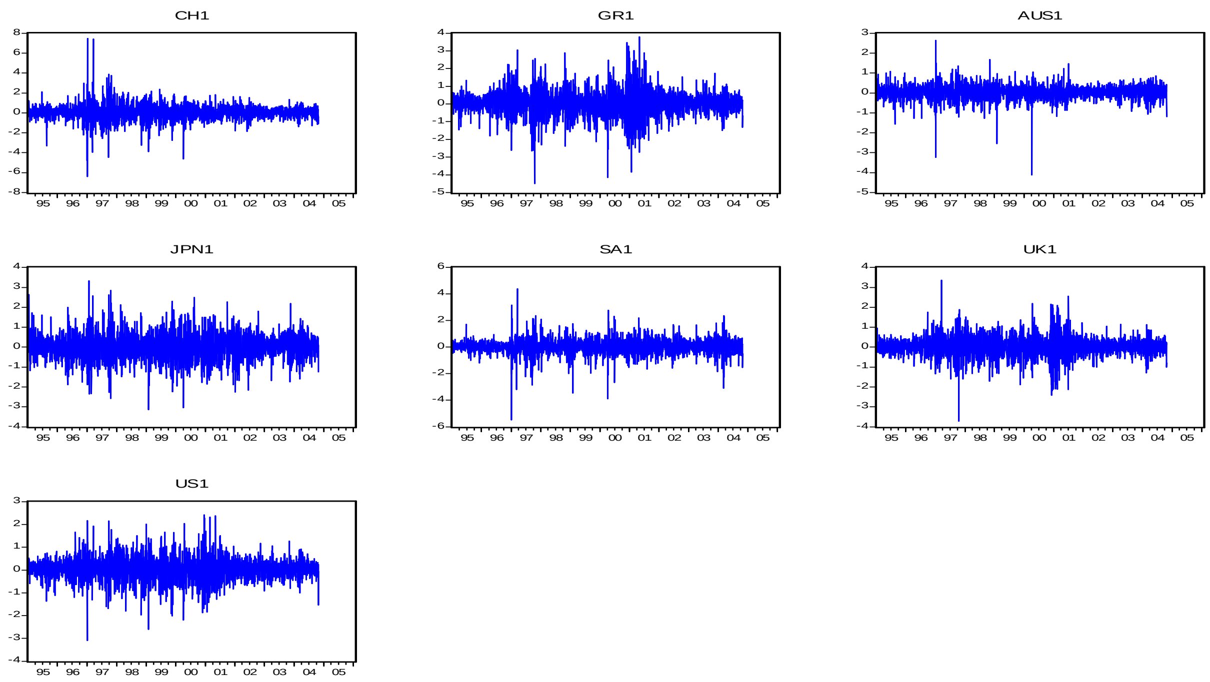


TABLE A4: BLOCK EXOGENEITY FOR RETURNS LINKAGES

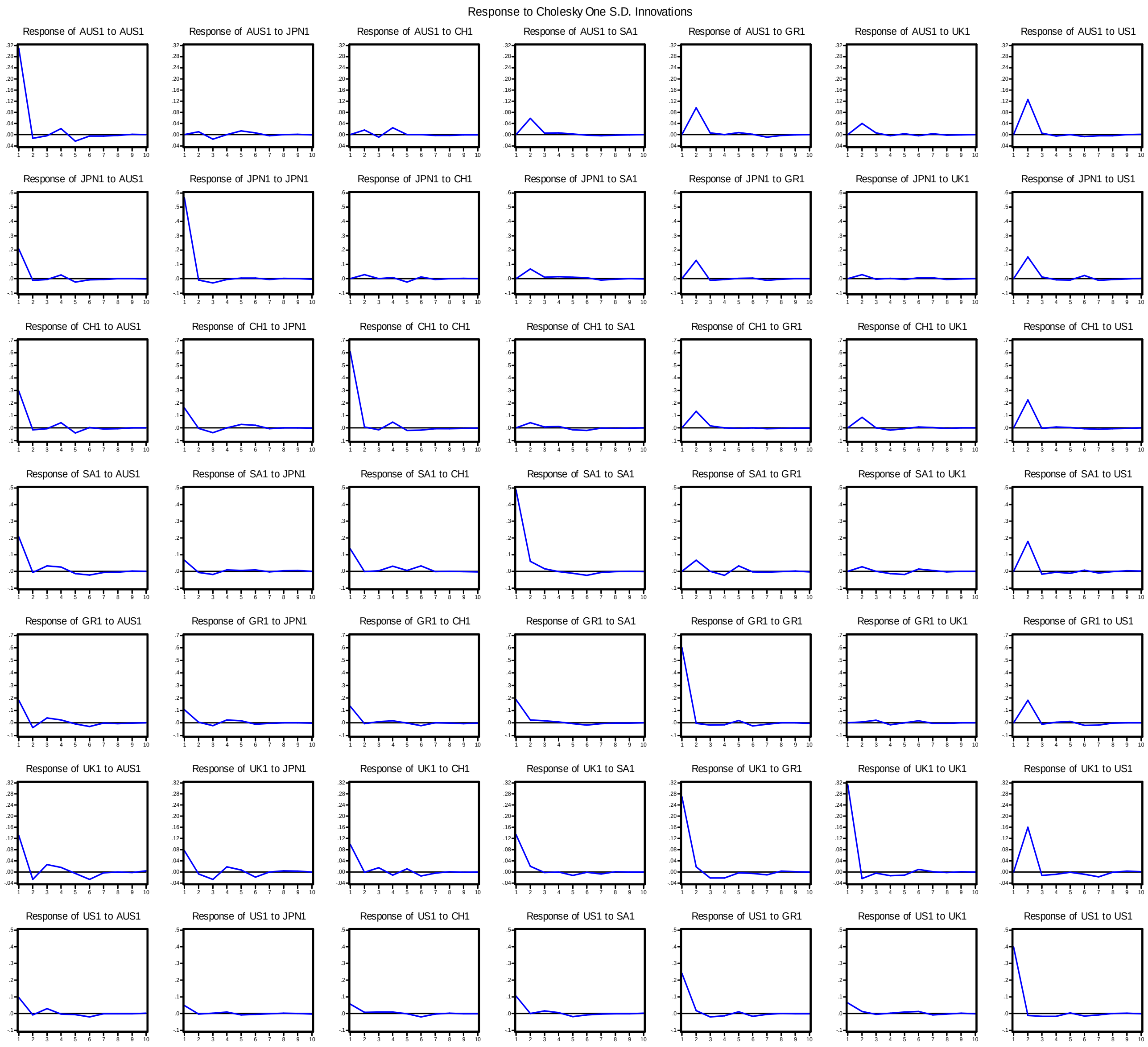
VAR Granger Causality/Block Exogeneity Wald Tests			
Date: 06/14/07 Time: 22:43			
Sample: 1/09/1995 1/17/2006			
Included observations: 2555			
Dependent variable: AUS1			
Excluded	Chi-sq	df	Prob.
JPN1	12.82186	5	0.0251
CH1	15.62086	5	0.0080
SA1	7.895253	5	0.1621
GR1	3.859575	5	0.5698
UK1	12.17643	5	0.0324
US1	422.5211	5	0.0000
All	**846.4428**	**30**	**0.0000**
Dependent variable: JPN1			
Excluded	Chi-sq	df	Prob.
AUS1	16.55462	5	0.0054
CH1	5.320436	5	0.3780
SA1	5.574674	5	0.3498
GR1	6.380200	5	0.2710
UK1	0.484804	5	0.9927
US1	168.0044	5	0.0000
All	**345.9580**	**30**	**0.0000**
Dependent variable: CH1			
Excluded	Chi-sq	df	Prob.
AUS1	11.96407	5	0.0353
JPN1	18.42519	5	0.0025
SA1	4.906567	5	0.4274
GR1	7.435262	5	0.1902
UK1	16.24294	5	0.0062
US1	268.1312	5	0.0000
All	**442.2403**	**30**	**0.0000**
Dependent variable: SA1			
Excluded	Chi-sq	df	Prob.
AUS1	19.32229	5	0.0017
JPN1	5.639348	5	0.3429
CH1	21.81527	5	0.0006
GR1	23.15761	5	0.0003
UK1	7.032386	5	0.2182
US1	282.5504	5	0.0000
All	**392.4654**	**30**	**0.0000**
Dependent variable: GR1			
Excluded	Chi-sq	df	Prob.
AUS1	14.68157	5	0.0118
JPN1	5.754083	5	0.3309
CH1	3.668910	5	0.5980
SA1	6.433146	5	0.2663
UK1	7.060864	5	0.2162
US1	185.3719	5	0.0000
All	**236.3430**	**30**	**0.0000**

Dependent variable: UK1			
Excluded	Chi-sq	df	Prob.
AUS1	18.96497	5	0.0020
JPN1	13.80842	5	0.0169
CH1	8.011619	5	0.1556
SA1	4.679652	5	0.4562
GR1	12.11889	5	0.0332
US1	294.6252	5	0.0000
All	**373.9495**	**30**	**0.0000**
Dependent variable: US1			
Excluded	Chi-sq	df	Prob.
AUS1	6.529214	5	0.2581
JPN1	1.492442	5	0.9139
CH1	5.667131	5	0.3400
SA1	10.83767	5	0.0547
GR1	3.240788	5	0.6629
UK1	5.131656	5	0.4000
All	**42.77161**	**30**	**0.0614**

TABLE A5: VARIANCE DECOMPOSITION FOR RETURNS LINKAGES

Variance Decomposition of US1:																
	I	II	I	II	I	II	I	II	I	II	II	II	I	II	I	II
Period	S.E.	S.E.	US1	US1	UK1	UK1	GR1	GR1	SA1	SA1	CH1	CH1	JPN1	JPN	AUS1	AUS1
5.00	0.50	0.50	98.67	63.69	0.19	1.66	0.03	23.65	0.73	4.60	0.09	1.36	0.06	2.77	0.23	4.04
10.00	0.50	0.50	98.35	63.38	0.20	1.73	0.15	23.62	0.77	4.60	0.22	1.50	0.07	2.91	0.25	4.16
20.00	0.50	0.50	98.35	63.38	0.20	1.73	0.15	23.62	0.77	4.60	0.22	1.50	0.07	2.92	0.25	4.16
Variance Decomposition of UK1:																
Period	S.E.	S.E.	US1	US1	UK1	UK1	GR1	GR1	SA1	SA1	CH1	CH1	JPN1	JPN1	AUS1	AUS1
5.00	0.50	0.50	30.40	10.24	73.38	68.30	0.36	29.32	0.21	7.27	0.34	4.00	0.56	2.51	0.74	7.39
10.00	0.51	0.51	30.46	10.31	70.82	67.41	0.42	29.13	0.26	7.24	0.55	4.07	0.69	2.52	0.80	7.63
20.00	0.51	0.51	30.46	10.31	68.82	67.01	0.42	29.13	0.26	7.24	0.55	4.07	0.69	2.52	0.80	7.63
Variance Decomposition of GR1:																
Period	S.E.	S.E.	US1	US1	UK1	UK1	GR1	GR1	SA1	SA1	CH1	CH1	JPN1	JPN1	AUS1	AUS1
5.00	0.71	0.71	28.93	6.74	14.76	0.15	61.92	72.65	0.36	3.02	0.25	2.61	0.18	1.43	0.60	7.32
10.00	0.71	0.71	29.03	6.82	15.59	0.22	63.80	72.29	0.44	3.03	0.33	2.56	0.19	1.45	0.62	7.43
20.00	0.71	0.71	30.03	6.82	17.59	0.22	62.80	72.29	0.44	4.03	0.33	2.68	0.19	1.45	0.62	7.43
Variance Decomposition of SA1:																
Period	S.E.	S.E.	US1	US1	UK1	UK1	GR1	GR1	SA1	SA1	CH1	CH1	JPN1	JPN1	AUS1	AUS1
5.00	0.59	0.59	18.13	9.41	5.19	0.34	1.90	1.70	69.17	68.77	6.90	5.46	0.21	4.97	0.50	10..90
10.00	0.59	0.59	18.05	9.38	6.13	0.41	1.95	1.70	68.80	68.42	7.14	5.69	0.23	5.03	0.70	9..96
20.00	0.59	0.59	18.05	9.38	6.14	0.41	1.95	1.70	68.80	68.42	7.15	5.69	0.23	5.04	0.70	9..96
Variance Decomposition of CH1:																
Period	S.E.	S.E.	US1	US1	UK1	UK1	GR1	GR1	SA1	SA1	CH1	CH1	JPN1	JPN1	AUS1	AUS1
5.00	0.75	0.75	15.71	8.86	6.34	1.38	1.34	3.18	6.96	0.40	68.59	65.45	0.54	0.48	0.52	15.77
10.00	0.76	0.76	15.72	8.86	6.33	1.39	1.34	3.18	7.00	0.46	68.41	65.33	0.66	0.49	0.54	15.75
20.00	0.76	0.76	15.72	8.86	6.33	1.39	1.34	3.18	7.00	0.46	68.41	65.33	0.66	0.87	0.54	15.75
Variance Decomposition of JPN1:																
Period	S.E.	S.E.	US1	US1	UK1	UK1	GR1	GR1	SA1	SA1	CH1	CH1	JPN1	JPN1	AUS1	AUS1
5.00	0.64	0.64	12.13	5.64	3.43	0.19	0.67	4.06	1.93	1.23	6.37	0.32	74.88	77.77	0.59	10.79
10.00	0.64	0.64	12.31	5.79	3.42	0.21	0.70	4.09	1.93	1.26	6.36	0.37	74.64	77.52	0.64	10.77
20.00	0.64	0.64	12.31	5.79	3.42	0.21	0.70	4.09	1.93	1.26	6.36	0.37	74.64	77.52	0.64	10.77
Variance Decomposition of AUS1:																
Period	S.E.	S.E.	US1	US1	UK1	UK1	GR1	GR1	SA1	SA1	CH1	CH1	JPN1	JPNI	AUS1	AUS1
5.00	0.36	0.36	24.01	12.32	3.51	1.32	0.56	7.21	5.88	2.66	6.80	0.75	2.70	0.45	56.54	75.29
10.00	0.36	0.36	24.08	12.36	3.51	1.34	0.63	7.26	5.87	2.68	6.78	0.76	2.72	0.47	56.41	75.13
20.00	0.36	0.36	24.08	12.36	3.51	1.34	0.63	7.26	5.87	2.68	6.78	0.76	2.72	0.49	56.41	75.13

FIGURE A2: IMPULSE RESPONSE FUNCTION FOR RETURNS LINKAGES



VOLATILITY LINKAGES RESULTS

TABLE A6: LAG SELECTION FOR VOLATILITY LINKAGES

VAR Residual Serial Correlation LM Tests		
H0: no serial correlation at lag order h		
Date: 06/09/07 Time: 23:45		
Sample: 1/09/1995 1/17/2006		
Included observations: 2534		
Lags	LM-Stat	Prob
1	64.70236	0.0657
2	65.55618	0.0613
3	75.07272	0.0097
4	48.20161	0.5054
5	73.82568	0.0125
6	63.23047	0.0832
7	83.42849	0.0016
8	64.88028	0.0638
9	63.39197	0.0832
10	67.34285	0.0420
11	63.53702	0.0793
12	69.51744	0.0944
13	86.81422	0.0007
14	73.79515	0.0125
15	76.13596	0.0078
16	72.04419	0.0118
17	81.33482	0.0025
18	77.53222	0.0058
19	69.87136	0.0267
20	87.98803	0.0005
21	61.87156	0.1025
22	61.10386	0.1150
23	75.90625	0.0082
24	64.93987	0.0632
25	**52.08011**	**0.3550**
26	75.52656	0.0088
27	54.29308	0.2798
28	48.31252	0.5009
29	62.06211	0.0996
30	43.47113	0.6960
Probs from chi-square with 49 df.		

TABLE A7: VAR RESULTS FOR VOLATILITY LINKAGES

	VOLAUS	**VOLCH**	**VOLJPN**	**VOLGR**	**VOLUK**	**VOLSA**	**VOLUS**
VOLAUS(-1)	0.678948	-0.181127	-0.132287	-0.099892	-0.060315		
	[23.8892]	[-2.90847]	[-3.67043]	[-1.88672]	[-2.24013]		
VOLAUS(-2)	0.126607	0.20429	0.106884	0.16251	0.097451		
	[3.59509]	[2.64738]	[2.39331]	[2.47710]	[2.92093]		
VOLAUS(-3)				0.355721	0.154864	0.301763	0.137441
				[5.37564]	[4.60195]	[3.54691]	[3.55903]
VOLAUS(-4)				-0.389194		-0.234791	
				[-5.81874]		[-2.73028]	
VOLAUS(-5)		-0.28737	-0.202434	-0.084951	-0.126047		-0.098109
		[-3.60902]	[-4.39286]	[-1.25490]	[-3.66139]		[-2.48339]
VOLAUS(-7)		0.240797					
		[3.00935]					
VOLAUS(-13)		-0.212489					
		[-2.65760]					
VOLAUS(-14)		0.197313	0.126179				
		[2.46400]	[2.72264]				
VOLAUS(-20)					0.099287		
					[2.87855]		
VOLAUS(-23)				0.140075	0.116121		
				[2.06773]	[3.37066]		
VOLAUS(-24)				-0.142221	-0.084052		-0.082977
				[-2.09569]	[-2.43547]		[-2.09516]
VOLAUS(-27)			-0.125742	-0.221133	-0.090699		
			[-2.75603]	[-3.29938]	[-2.66105]		
VOLCH(-1)		1.029917			-0.02338	-0.101526	
		[39.4076]			[-2.06915]	[-3.55396]	
VOLCH(-2)					0.034567	0.136085	0.045436
					[2.07595]	[3.23264]	[2.37782]
VOLCH(-3)	0.079907	0.18239			-0.048859	0.228724	
	[4.52900]	[4.71773]			[-2.92310]	[5.41255]	
VOLCH(-4)	-0.054802	-0.176187	-0.045755		-0.002933	-0.230694	
	[-3.08847]	[-4.53144]	[-2.03339]		[-0.17445]	[-5.42821]	
VOLCH(-5)		0.102157		0.142339	0.05458	0.11409	0.052104
		[2.61453]		[4.28494]	[3.23091]	[2.67135]	[2.68773]
VOLCH(-6)		-0.191392				-0.102984	
		[-4.86872]				[-2.39671]	
VOLCH(-7)	-0.042396			-0.082486	-0.039221	-0.104384	
	[-2.35133]			[-2.45571]	[-2.29609]	[-2.41709]	
VOLCH(-8)			-0.046628		0.049465	0.010143	0.048164
			[-2.03490]		[2.88963]	[0.23438]	[2.45180]
VOLCH(-9)					-0.021166	0.132931	
					[-1.23287]	[3.06267]	
VOLCH(-14)	0.044226	-0.080983			0.042293		0.040552
	[2.44430]	[-2.04261]			[2.46729]		[2.06154]
VOLCH(-15)		0.123331					-0.044253
		[3.11325]					[-2.25150]
VOLCH(-19)				0.107587	0.06256		
				[3.19723]	[3.65582]		
VOLCH(-20)				-0.104233	-0.051754		
				[-3.09717]	[-3.02395]		
VOLCH(-21)							-0.057921
							[-2.96398]
VOLCH(-27)		0.159591	0.050066				

		[4.15507]	[2.25232]				
VOLJPN(-1)	0.056039		0.890426	0.080242			
	[3.12314]		[39.1320]	[2.40057]			
VOLJPN(-2)	-0.073046				-0.052723		
	[-3.06200]				[-2.33290]		
VOLJPN(-3)			0.080004				
			[2.63427]				
VOLJPN(-4)			-0.097723				
			[-3.22249]				
VOLJPN(-5)			0.070499				
			[2.31771]				
VOLJPN(-6)							0.056786
							[2.17724]
VOLJPN(-7)		-0.131972				-0.119439	
		[-2.51260]				[-2.08040]	
VOLJPN(-11)	0.068602			0.105954			
	[2.87212]			[2.38122]			
VOLJPN(-12)	-0.049873			-0.033911			
	[-2.08822]			[-0.76220]			
VOLJPN(-18)			-0.064581	-0.133151	-0.038474	-0.02796	-0.065449
			[-2.13881]	[-3.00184]	[-1.70562]	[-0.49027]	[-2.52834]
VOLJPN(-19)			0.013949	0.030169	0.001434	0.053656	0.043546
			[0.46087]	[0.67855]	[0.06342]	[0.93865]	[1.67830]
VOLSA(-1)	0.027103	0.114403	0.038418	0.047273	0.02506	1.064439	
	[2.30140]	[4.43328]	[2.57241]	[2.15473]	[2.24612]	[37.7368]	
VOLSA(-3)	-0.0484	-0.089464	-0.068346	-0.074231	-0.058583	-0.230102	-0.05492
	[-2.90604]	[-2.45146]	[-3.23600]	[-2.39253]	[-3.71293]	[-5.76837]	[-3.03314]
VOLSA(-4)				0.089898	0.033596	0.116471	
				[2.87365]	[2.11175]	[2.89577]	
VOLSA(-5)	0.036181		0.063208				
	[2.15179]		[2.96433]				
VOLSA(-7)						0.164722	
						[4.04811]	
VOLSA(-9)	-0.038107	-0.169612				-0.082536	
	[-2.22494]	[-4.51950]				[-2.01202]	
VOLSA(-10)		0.152635	0.044168			0.088357	
		[4.05077]	[2.02541]			[2.14525]	
VOLSA(-11)		-0.109955					
		[-2.90528]					
VOLSA(-12)					0.033309		0.049525
					[2.03461]		[2.63609]
VOLSA(-14)		0.077508	-0.051571				
		[2.04995]	[-2.35680]				
VOLSA(-15)			0.054261				
			[2.48048]				
VOLSA(-21)				0.09832	0.049198		0.07802
				[3.07228]	[3.02300]		[4.17754]
VOLSA(-22)			0.054661				
			[2.50472]				
VOLSA(-23)				-0.157709	-0.065242		-0.050786
				[-4.91998]	[-4.00225]		[-2.71484]
VOLSA(-24)				0.079767	0.04725		
				[2.48562]	[2.89527]		
VOLSA(-25)			-0.060968		-0.032825		
			[-2.79028]		[-2.01091]		
VOLGR(-1)	-0.03014	-0.148773	0.023926	0.785244		-0.241689	
	[-1.91527]	[-4.31446]	[1.19890]	[26.7855]		[-6.41231]	

VOLGR(-2)				0.208154		0.156152	
				[5.46069]		[3.18619]	
VOLGR(-3)	0.052091	0.09674			0.058418	0.174415	
	[2.51166]	[2.12874]			[2.97325]	[3.51124]	
VOLGR(-5)	-0.057558	-0.097038		-0.115693	-0.058762	-0.110209	-0.051379
	[-2.76671]	[-2.12872]		[-2.98523]	[-2.98153]	[-2.21182]	[-2.27170]
VOLGR(-6)			0.084397	0.138448			
			[3.19408]	[3.56683]			
VOLGR(-13)					0.078861		
					[4.00890]		
VOLGR(-14)				-0.120591	-0.113707		
				[-3.09642]	[-5.74121]		
VOLGR(-15)	0.057517			0.086328		0.111563	
	[2.72962]			[2.19925]		[2.21057]	
VOLGR(-19)		-0.106269					
		[-2.32462]					
VOLGR(-20)	0.045044	0.135634					
	[2.16085]	[2.96941]					
VOLGR(-26)	-0.042372		-0.073117	-0.233079	-0.104686		-0.069876
	[-2.04929]		[-2.78853]	[-6.05113]	[-5.34438]		[-3.10856]
VOLUK(-1)					0.763861	0.166127	0.1059
					[27.3525]	[2.35295]	[3.30447]
VOLUK(-2)					0.202225		-0.02343
					[5.73518]		[-0.57905]
VOLUK(-3)						-0.200784	
						[-2.23293]	
VOLUK(-5)					0.072346		
					[2.02457]		
VOLUK(-8)				0.167778		0.186083	
				[2.39668]		[2.06749]	
VOLUK(-9)				-0.192176			
				[-2.74138]			
VOLUK(-10)			-0.122611		-0.098803		
			[-2.56614]		[-2.76804]		
VOLUK(-11)			0.106294				-0.11236
			[2.22900]				[-2.74842]
VOLUK(-12)							0.004448
							[0.10846]
VOLUK(-15)							0.184655
							[4.52645]
VOLUK(-17)			-0.10238				-0.141572
			[-2.16579]				[-3.49341]
VOLUK(-20)				0.137311	0.082936		0.124661
				[2.00622]	[2.38279]		[3.12102]
VOLUK(-21)			-0.121766	-0.203295	-0.123215		-0.003151
			[-2.62554]	[-2.98398]	[-3.55634]		[-0.07926]
VOLUK(-29)						-0.188394	
						[-2.23100]	
VOLUK(-30)						0.155443	
						[2.33509]	
VOLUS(-1)	0.33023	0.746204	0.271172	0.389368	0.312429	0.889297	0.882664
	[15.1435]	[15.6165]	[9.80596]	[9.58476]	[15.1232]	[17.0267]	[37.2315]
VOLUS(-2)	-0.246399	-0.492921	-0.229337	-0.222844	-0.219495	-0.666299	
	[-8.58936]	[-7.84181]	[-6.30422]	[-4.16999]	[-8.07663]	[-9.69763]	
VOLUS(-3)		-0.183377		-0.134314	-0.12728	-0.272697	-0.13148
		[-2.80039]		[-2.41262]	[-4.49573]	[-3.80987]	[-4.04688]
VOLUS(-4)	-0.084044	-0.150246					0.069067

	[-2.78885]	[-2.27530]					[2.10814]
VOLUS(-5)						0.163353	
						[2.25464]	
VOLUS(-7)				0.118735			
				[2.10841]			
VOLUS(-8)				0.186706	0.114663		0.073824
				[3.32297]	[4.01296]		[2.25144]
VOLUS(-9)			-0.105974		-0.070384		
			[-2.76387]		[-2.45721]		
VOLUS(-10)				-0.121509			
				[-2.15412]			
VOLUS(-12)						-0.219684	
						[-3.03694]	
VOLUS(-13)				0.28199		0.391527	
				[4.99682]		[5.39615]	
VOLUS(-14)						-0.151212	
						[-2.06312]	
VOLUS(-19)		0.170212		0.159897	0.091973		0.07787
		[2.53921]		[2.80571]	[3.17347]		[2.34136]
VOLUS(-20)		-0.226214	-0.083848	-0.126281	-0.140776		-0.097611
		[-3.38710]	[-2.16930]	[-2.22404]	[-4.87535]		[-2.94574]
VOLUS(-22)				-0.155691	-0.075552		
				[-2.73222]	[-2.60717]		
							0.087256
							[2.62612]
VOLUS(-29)				0.155075	0.106247		
				[2.76262]	[3.72192]		
VOLUS(-30)				-0.112433	-0.060405		
				[-2.45453]	[-2.59309]		
C	0.012162	0.00705	0.016865	0.004715	0.004258	0.020385	0.011711
	[4.25829]	[1.12660]	[4.65654]	[0.88621]	[1.57367]	[2.98004]	[3.77169]

Note: reported in [ ] are the t-statistics

TABLE A8: BLOCK EXOGENEITY FOR VOLATILITY LINKAGES

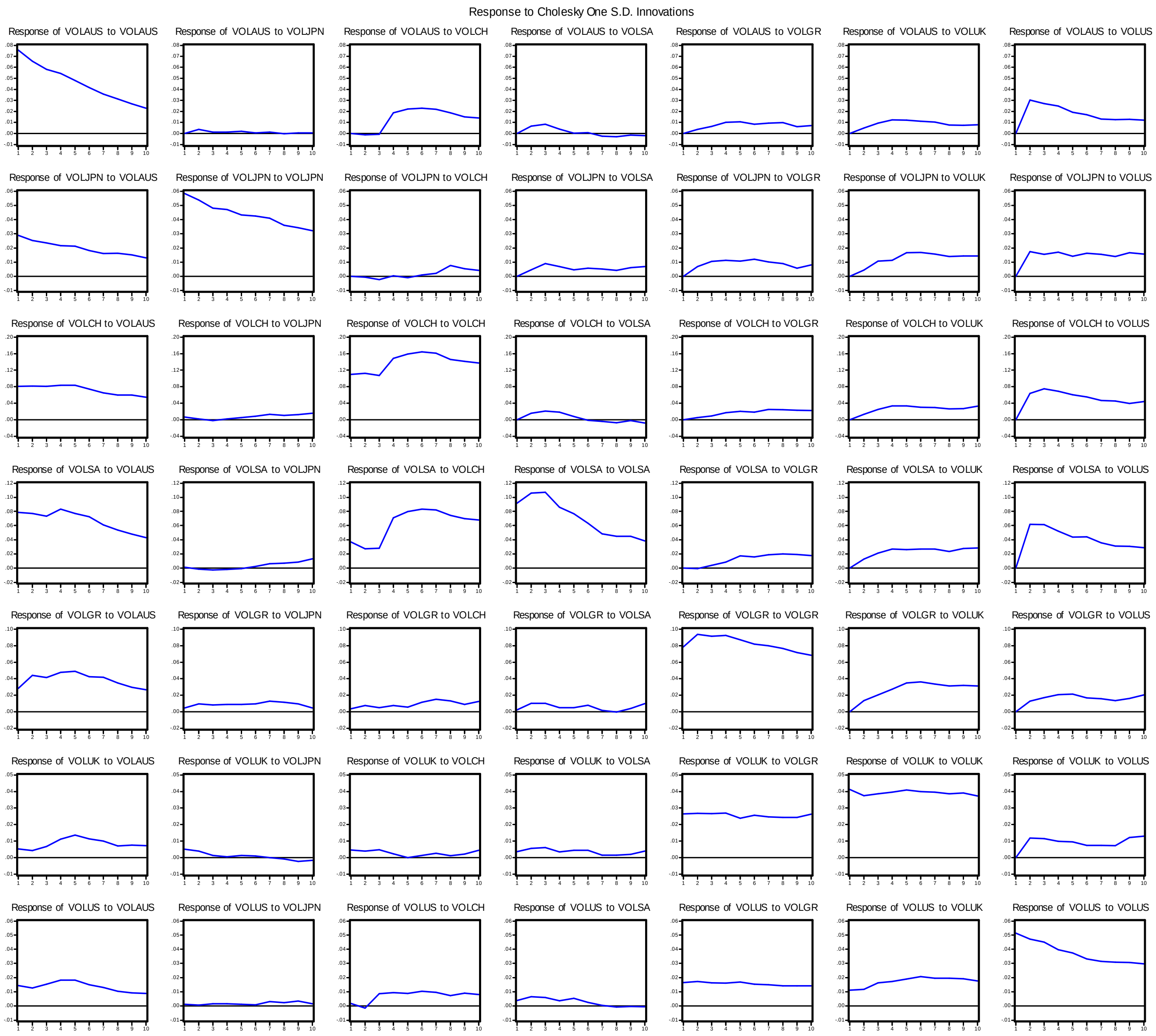
VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 1/09/1995 1/17/2006	Included observations: 2535		
Dependent variable: VOLAUS			
Excluded	Chi-sq	df	Prob.
VOLJPN	36.05243	25	0.0708
VOLCH	109.6601	25	0.0000
VOLSA	36.323	25	0.0668
VOLGR	32.90743	25	0.1334
VOLUK	25.10907	25	0.4563
VOLUS	420.9297	25	0.0000
All	**749.7703**	**150**	**0.0000**
Dependent variable: VOLJPN			
Excluded	Chi-sq	df	Prob.
VOLAUS	52.91249	25	0.0009
VOLCH	75.40656	25	0.0000
VOLSA	46.81565	25	0.0052
VOLGR	28.72169	25	0.2757
VOLUK	65.17455	25	0.0000
VOLUS	192.1371	25	0.0000

All	**635.1698**	**150**	**0.0000**
Dependent variable: VOLCH			
Excluded	Chi-sq	df	Prob.
VOLAUS	64.62144	25	0.0000
VOLJPN	32.21422	25	0.1519
VOLSA	88.20449	25	0.0000
VOLGR	68.44114	25	0.0000
VOLUK	41.42422	25	0.0207
VOLUS	600.9472	25	0.0000
All	**1011.556**	**150**	**0.0000**
Dependent variable: VOLSA			
Excluded	Chi-sq	df	Prob.
VOLAUS	27.43702	25	0.3344
VOLJPN	28.3325	25	0.2928
VOLCH	258.3081	25	0.0000
VOLGR	83.67085	25	0.0000
VOLUK	39.0249	25	0.0366
VOLUS	667.9964	25	0.0000
All	**1207.028**	**150**	**0.0000**
Dependent variable: VOLGR			
Excluded	Chi-sq	df	Prob.
VOLAUS	63.50702	25	0.0000
VOLJPN	46.38598	25	0.0058
VOLCH	121.0581	25	0.0000
VOLSA	142.7103	25	0.0000
VOLUK	116.4522	25	0.0000
VOLUS	165.6768	25	0.0000
All	**717.6778**	**150**	**0.0000**
Dependent variable: VOLUK			
Excluded	Chi-sq	df	Prob.
VOLAUS	117.6063	25	0.0000
VOLJPN	73.16035	25	0.0000
VOLCH	200.2838	25	0.0000
VOLSA	155.044	25	0.0000
VOLGR	105.6389	25	0.0000
VOLUS	266.3825	25	0.0000
All	**894.1316**	**150**	**0.0000**
Dependent variable: VOLUS			
Excluded	Chi-sq	df	Prob.
VOLAUS	35.19582	25	0.0847
VOLJPN	32.0749	25	0.1559
VOLCH	121.9161	25	0.0000
VOLSA	64.27034	25	0.0000
VOLGR	58.96956	25	0.0001
VOLUK	76.48497	25	0.0000
All	**369.8103**	**150**	**0.0000**

TABLE A9: VARIANCE DECOMPOSITION FOR VOLATILITY LINKAGES

Variance Decomposition of VOLUS:																
Period	S.E.	S.E.	VOLUS	VOLUS	VOLUK	VOLUK	VOLGR	VOLGR	VOLSA	VOLSA	VOLCH	VOLCH	VOLJPN	VOLJPN	VOLAUS	VOLAUS
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5	0.12	0.12	96.14	70.01	2.03	8.43	0.02	9.80	0.77	0.96	0.96	1.74	0.02	0.05	0.06	9.01
10	0.15	0.15	92.40	64.11	4.92	13.30	0.15	10.61	0.58	0.62	1.85	2.81	0.03	0.16	0.06	8.40
20	0.18	0.18	89.96	61.37	6.14	14.03	0.20	13.91	0.97	0.59	2.21	3.34	0.27	0.13	0.26	6.63
Variance Decomposition of VOLUK:																
Period	S.E.	S.E.	VOLUS	VOLUS	VOLUK	VOLUK	VOLGR	VOLGR	VOLSA	VOLSA	VOLCH	VOLCH	VOLJPN	VOLJPN	VOLAUS	VOLAUS
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5	0.11	0.11	26.97	3.72	71.83	63.56	0.03	27.68	0.11	0.91	0.08	0.51	0.19	0.35	0.79	3.27
10	0.15	0.15	27.75	3.90	70.67	64.20	0.05	27.34	0.11	0.65	0.06	0.40	0.50	0.22	0.86	3.28
20	0.20	0.20	32.83	6.69	63.38	54.63	0.91	34.38	0.64	0.69	0.31	0.89	0.80	0.40	1.14	2.32
Variance Decomposition of VOLGR:																
Period	S.E.	S.E.	VOLUS	VOLUS	VOLUK	VOLUK	VOLGR	VOLGR	VOLSA	VOLSA	VOLCH	VOLCH	VOLJPN	VOLJPN	VOLAUS	VOLAUS
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5	0.23	0.23	28.63	2.52	27.75	4.79	42.47	74.12	0.52	0.49	0.09	0.34	0.13	0.65	0.41	17.09
10	0.31	0.31	30.33	2.83	33.12	8.24	35.17	70.65	0.50	0.45	0.41	0.99	0.18	0.87	0.30	15.98
20	0.38	0.38	34.11	5.34	32.31	8.57	31.08	71.62	1.03	0.59	0.34	1.20	0.24	0.76	0.89	11.92
Variance Decomposition of VOLSA:																
Period	S.E.	S.E.	VOLUS	VOLUS	VOLUK	VOLUK	VOLGR	VOLGR	VOLSA	VOLSA	VOLCH	VOLCH	VOLJPN	VOLJPN	VOLAUS	VOLAUS
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5	0.32	0.32	27.38	11.82	1.18	1.93	0.50	0.36	67.09	42.81	2.89	13.75	0.36	0.01	0.60	29.30
10	0.41	0.41	27.46	10.62	3.20	3.25	0.46	1.19	58.77	32.72	7.97	25.01	0.36	0.21	1.78	27.00
20	0.47	0.47	26.88	9.60	4.88	4.30	0.55	1.88	54.94	28.38	10.35	29.16	0.56	0.22	1.85	26.45
Variance Decomposition of VOLCH:																
Period	S.E.	S.E.	VOLUS	VOLUS	VOLUK	VOLUK	VOLGR	VOLGR	VOLSA	VOLSA	VOLCH	VOLCH	VOLJPN	VOLJPN	VOLAUS	VOLAUS
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5	0.37	0.37	26.07	12.91	1.39	2.13	0.43	0.57	23.32	0.78	46.86	59.62	0.65	0.06	1.28	23.93
10	0.54	0.54	21.92	9.91	2.56	2.48	0.36	1.15	17.95	0.42	53.83	67.46	0.56	0.28	2.82	18.29
20	0.66	0.66	20.21	8.78	2.72	2.39	0.38	1.24	15.91	0.47	57.36	69.61	0.43	0.45	2.98	17.06
Variance Decomposition of VOLJPN:																
Period	S.E.	S.E.	VOLUS	VOLUS	VOLUK	VOLUK	VOLGR	VOLGR	VOLSA	VOLSA	VOLCH	VOLCH	VOLJPN	VOLJPN	VOLAUS	VOLAUS
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5	0.13	0.13	16.05	5.77	4.55	3.00	1.08	2.24	4.61	0.93	0.76	0.04	72.47	71.48	0.49	16.55
10	0.17	0.17	20.39	7.73	7.07	5.74	0.71	2.84	4.28	1.11	0.90	0.40	65.55	67.74	1.10	14.43
20	0.20	0.20	24.10	9.53	7.43	5.84	0.80	3.73	6.10	2.30	1.78	2.60	57.22	62.08	2.57	13.93
Variance Decomposition of VOLAUS:																
Period	S.E.	S.E.	VOLUS	VOLUS	VOLUK	VOLUK	VOLGR	VOLGR	VOLSA	VOLSA	VOLCH	VOLCH	VOLJPN	VOLJPN	VOLAUS	VOLAUS
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5	0.15	0.15	32.28	11.49	0.99	1.80	4.44	1.17	24.73	0.55	8.44	3.66	3.17	0.09	56.57	81.24
10	0.18	0.18	33.26	11.30	1.88	2.58	4.22	1.91	23.06	0.47	14.24	8.22	2.37	0.07	56.44	75.45
20	0.19	0.19	33.01	11.21	1.94	2.71	4.18	2.05	21.40	1.15	17.39	9.71	2.11	0.13	56.44	73.05

FIGURE A3: IMPULSE RESPONSE FUNCTIONS FOR VOLATILITY LINKAGES



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