VOLATILITY TRANSMISSION ACROSS SOUTH AFRICAN FINANCIAL MARKETS: DOES THE BULL – BEAR DISTINCTION MATTER?

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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 purposes.

ABSTRACT

The volatility transmission in financial markets has important implications for investment decision making, portfolio diversification and overall macroeconomic stability. This paper analyses volatility transmission across four South African financial markets that is the stock, bond , money and foreign exchange markets, using daily data for the period 2000-2010. It also shows whether the volatilities in the SA financial markets present a different behaviour in bull and bear market phases. The effects of the international markets volatility to the local markets volatility was also looked at in this study. To obtain estimates of market volatility, the study experimented with various volatility models that include the GARCH, EGARCH and TARCH. To examine volatility interaction and the transmission of volatility shocks, a VAR model was estimated together with block exogeneity, impulse response and variance decomposition.

The study found that there is limited volatility transmission across the SA financial markets. The study also found that the money market is the most exogenous of all markets since the other three financial markets volatility is insignificant to the money market (see impulse response results). For the bond market, volatility transmission was characterized with a decreasing trend. With regard to international markets volatility, it concluded that, the shocks in the international markets will eventually affect the movement in the local markets. The results also highlighted that, world and local markets are important in accelerating the volatility transmission in SA financial markets depending on whether they are in their bull or bear phases. In the case of South Africa, the study found that volatility transmission across markets is higher during bear market periods than bull market periods.

Basing on the study results which show that the volatility transmission is limited across SA financial markets, the implication to local and international investors is that there is a greater potential for diversifying risk by investing in different South African financial markets.

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CHAPTER 1

INTRODUCTION

1.1 CONTEXT OF RESEARCH

Developments in financial markets for example technology and communication improvement have led to a growing interest in studying and analyzing volatility transmissions in financial markets. Fleming, Kirby and Ostdiek (1997), argue that portfolio managers transfer funds from stocks into bonds when they expect stock market volatility to increase. The risk reduction gained from funds transfer from one market to another, when market volatility is expected to increase, depends on the volatility linkages between the financial markets.

Volatility transmission is also important for determining monetary policy efficiency and in addressing financial stability issues. The extent to which volatility is transmitted across markets could result in a large shock in one market destabilizing another market. For financial stability interest, volatility can be useful in determining different market price interrelationships, where the complexities signify a potential source of systemic financial instability (Hurditt, 2004).

In financial markets volatility transmission is also an important factor behind macroeconomic policy implementation (Chinzara and Aziakpono, 2008). The analysis of the volatility transmission across markets can be applied to determine whether financial markets are efficient and for determining returns and volatility in a market, or between different markets (Brooks, 2008: 383).

Various studies have documented common occurrence of financial markets volatility transmission. Fleming, *et al* (1997) estimated a stochastic volatility of the trading model using General Methods of Moments in the US and their results showed that specification explained most of the data's properties, producing strong volatility linkages between the stock, bond and money market.

Fleischer (2003) examined information and volatility linkages across the equity, money and bond markets within Australia. The general method of moments was used in this study. Fleischer’s study found that there is a strong relationship between the equity and money markets and the equity and bond markets.

A study by Ebrahim (2000) used the trivariate generalized autoregressive conditional heteroscedasticity (T-GARCH) models to study price and volatility spillovers between the foreign exchange and associated money markets. Three models were estimated using data on the U.S. dollar/Canadian dollar, U.S. dollar/Deutsche mark and U.S. dollar/Japanese yen daily exchange rate returns together with associated 90-day Eurocurrency market returns in order to determine whether price and volatility spillover exists between the markets. The paper found strong evidence of price and volatility spillovers in all 3 models and some volatility spillovers were found to be asymmetric.

Antell (2004) used weekly data for the period January 9, 1991 to December 30, 2003 to test the strength of volatility linkages between Finnish stock, bond and money markets. The study used both generalized methods of moments (GMM) and a vector-autoregressive EGARCH specification. The results showed that linkages between the stock-bond and stock-money market pairings were surprisingly low, even negative in some cases and weaker than the return correlations. On the other hand, the bond-money market pairing exhibited a strong, yet not perfect volatility link. The study found that the stock market had the most 'independent' volatility, influencing both the bond volatility and the money market volatility. Furthermore the study found that, money market volatility was negatively affected both by the stock market and the bond market component.

A study by Yang and Doong, (2004) adopted a bivariate EGARCH framework and investigated the dynamic price and volatility spillovers between stock prices and exchange rates for the G-7 countries. The results from the bivariate EGARCH model were such that, for the first moment interdependencies, there were significant price spillovers from foreign exchange to the stock market for Canada and Japan. Turning to the second moment interdependencies, the authors established that there exist volatility spillover from the stock to foreign exchange markets for France, Italy, Japan and the US and no volatility spillover was found from the foreign exchange to the stock markets at all.

Hurditt (2004) studied volatility transmission across Jamaican financial markets. He argued that there is presence of high levels of common market returns volatility relative to cross-market spillovers, within the Jamaican financial system. Foreign exchange market displayed the most distinct common market volatility spillovers, followed by the stock market and having strong common market spillover, relative to the bond market indicates uncertainty force, as a usual feature of risky markets. The author also concluded that cross-market spillover effects, due to changes in the liquidity conditions have a smaller influence on spillovers to the bond market than for the foreign exchange and the stock markets.

Most studies on volatility in sub-Saharan Africa have mainly focused on returns linkages, information flow and volatility transmission of financial markets between countries for not more than three markets (for example Lamba and Otchere 2001; Chinzara and Aziakpono, 2008 and Piesse and Hearn, 2002). The proposed research differs in that it considers four major markets in South Africa. The South African financial markets are of interest, because they are Africa's most developed and the possibility of diversifying within the South African markets is very high.

1.2 OBJECTIVES OF THE STUDY

The main objective of the research is to analyse the volatility transmission across South African financial markets. These financial markets include the stock market, bond market, money market and the foreign exchange market. The specific goals of the study are as follows:

- To examine the volatility transmission among the South African four financial markets;
- To examine the long run trends in volatility in each of the markets so as to determine whether volatility transmission is increasing or decreasing;
- To identify the dominant source of volatility within the domestic financial markets;
- To identify whether a risk-return relationship exist in each of the financial markets;
- To examine whether international markets (control variables) affect the volatility in the SA financial markets.
- To show whether the volatilities in the SA financial markets present a different behaviour in bull and bear phases.
- To articulate the policy and investment implication of the findings.

1.3 CONTRIBUTION AND MOTIVATION OF THE STUDY

While many studies look at international financial markets, domestic rarely exist for South Africa. One that exists on local financial markets is notably by Shikwambana, (2007). We built on this study but we address and extent some of the issues. Unlike previous studies, we have looked at the interaction between all the four South African financial markets. Another contribution is that we have also included foreign financial markets to see whether the behaviour of the foreign markets affects the local markets movements.

In addition, we have distinguished between the bull and bear periods and this in important in that it shows whether the financial markets volatilities present a different behaviour in bull and bear phases. This paper is also distinct from previous studies in that very high frequency data (daily) is employed. This is because it is our considered view that financial markets reacts promptly to news and thus low frequency would fail to capture such dynamics.

Since the financial markets are very vital in the economy of the country. Knowing the volatility transmission across the South African financial markets could be very helpful to policy makers and investors who wish to invest in any of the financial markets.

1.4 METHODS OF THE STUDY

In order to provide a comprehensive understanding of the volatility transmission across financial markets, a detailed literature review will be done. A survey of both theoretical and empirical studies elsewhere and in South Africa will be undertaken as background to the research.

Prior to the application of the formal econometric methodology, several descriptive statistical tests shall be done, namely mean, variance, standard deviation, skewness, kurtosis and normality of the data. The purpose of this would be to check the behaviour of the data before applying the formal model. The study will predominantly use various financial econometrics techniques. To obtain estimates of market volatility, the study will experiment with various volatility models which include the GARCH (1, 1), GRJ GARCH (or TARCH) and exponential GARCH (EGARCH), because most authors in this field apply these econometric methods as they appropriately capture time varying volatility and volatility clustering[1]. The best model among the three will then be used to generate volatility (conditional variance) series. Volatility series will then be analysed using the Vector Autoregressive (VAR) methodology together with block exogeneity, impulse response and variance decomposition to examine the speed and magnitude of the volatility transmission. We shall also include the international markets as our control variables to see whether the volatility transmission between South African financial markets is affected by the behaviour in international financial markets and to see if the volatility linkage of domestic financial markets is robust. Finally the study will also look at the transmission differences between bull and bear markets.

As proxies for the stock, bond, foreign exchange and money markets, we used the FTSE/JSE all share, All bond index, MSCI ZAR to 1 USD and the SA T-bill 91 days (tender rates) respectively. For international markets we have used the FTSE global bond index, MSCI world stock index and the London interbank lending rate (LIBOR) as our control variables for the bond, stock and money market respectively. The choice of these indices is motivated by the fact that they are the best representative indices for the selected markets.

The study will use daily closing prices for each market, obtained from Thompson DataStream. We will utilize daily market indices for the period from January 2000 to April 2010.Daily frequency 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.

1.5 ORGANISATION OF THE STUDY

This study is organized as follows: The next chapter reviews both theoretical and empirical literature regarding volatility transmission among financial markets. This chapter is divided into different sections, particularly the roles of financial markets in the economy, types of financial markets, nature of linkages and interaction between financial markets and finally the empirical literature. Chapter 3 discusses the relationship between the financial markets and also a comparative analysis of the SA financial markets. Chapter 4 discusses the econometric models that are available to model volatility transmission i.e. Vector Autoregressive (VAR) and

[1] Prior to use of the GARCH we analyse the features of our data to see whether it contains properties necessary to use GARCH models.

Generalized Autoregressive Conditional Heteroscedasticity (GARCH). The chapter also focuses on the models that are employed in this study as well as the data and estimation techniques. The results of the study are presented and discussed in Chapter 5 and finally Chapter 6 provides a summary of the main findings, policy proposals and recommendations based on the findings as well as suggesting further research areas.

CHAPTER 2

THEORETICAL ISSUES AND LITERATURE SURVEY

2.1 INTRODUCTION

This chapter considers both theoretical and empirical literature on the various issues regarding volatility transmission among financial markets. Section 2.2 discusses the financial markets, specifically focusing on the major functions, organisation and the types of financial markets. These functions include: helping in facilitating trades of goods and services, reducing information and transaction costs in trade and helps the payments, producing information on the investment projects and diversification of risk.

Section 2.3 discusses volatility transmission and its importance; Section 2.4 reviews the nature of the possible returns and volatility linkages that might exist between financial markets; Section 2.5 reviews the theoretical linkages and interaction between financial markets; Section 2.6 reviews the empirical literature regarding volatility transmission between financial markets and section 2.7 concludes the chapter.

2.2 FINANCIAL MARKETS

Financial markets provide the infrastructure and mechanism for the buying and selling of securities. In terms of structure and organisation, financial markets can be broadly classified into the primary market and the secondary markets. The markets can be further divided the money market, the capital market (equity and bond markets) and the foreign exchange market (Faure, 2005:69). The first part of the subsection discusses the role of financial markets. The second part of the section discusses the broad classification of financial markets, i.e. primary and secondary markets, highlighting the major differences between the two. The third part discusses the various financial markets and the actors involved in these markets.

2.2.1 Roles of financial markets

In many ways, financial markets fulfil a similar role to financial intermediaries. However, certain key features of financial markets, for example liquidity and tradability, distinguish them from financial intermediaries. Through their contribution to risk management, financial markets help promote public policy goals like sustainability, stability and security. They do so because risk management generates social as well as private returns attractive new business opportunities (Kaul, 2006). Financial markets allow income and consumption to be moved across time. For instance, individuals can borrow to consume more today or invest/lend to spend more in the future, firms can borrow to finance production now and receive payment for finished goods later, governments can also borrow to finance social programs (Kaul, 2006).

Financial markets can also help in facilitating trades of goods and services. An efficient financial system reduces information and transaction costs in trade and helps the payments. They can also increase saving mobilisation by an improvement of the savers confidence. Furthermore financial markets produce information on the investment projects. It can be difficult to obtain reliable information on the projects or on the borrowers. The financial system can reduce this issue by devoting some agents to the screening of projects. Financial markets favour the monitoring during all the investment process and develop a corporate governance control. In fact the financial system has to deal with two kinds of information asymmetries which include adverse selection problem and moral hazard (Cairo, 2008).

2.2.2 Primary and secondary markets

Considering the role of financial markets, a distinction can be made between the primary and secondary markets. A primary market is a financial market in which new issues of a security, such as a bond or a stock, are sold to initial buyers by the corporation or government agency borrowing the funds. A secondary market is a financial market in which securities that have been previously issued (and are thus secondhand) can be resold (Ansari, 2006).

The primary market is the market where new securities like bonds and shares are issued and sold to initial buyers by corporations or the government. According to Ansari (2006) the primary markets for securities are not well known to the public because the selling of securities to initial buyers often takes place behind closed doors. An important financial institution that assists in the initial sale of securities in the primary market is the investment bank. It does this by underwriting securities: It guarantees a price for a corporation’s securities and then sells them to the public. This is the market in which companies can raise capital for investment and expansion. The primary markets consist of a network of dealers, commercial and investment banks that offer and trade in securities over the counter (OTC).

A market where investors purchase securities or assets from other investors, rather than from issuing companies themselves is known as a secondary market. Examples of secondary markets are foreign exchange markets, future markets and options markets. Securities brokers and dealers are crucial to a well-functioning secondary market (Mishkin, 2004). When an individual buys a security in the secondary market, the person who has sold the security receives money in exchange for the security, but the corporation that issued the security acquires no new funds. A corporation acquires new funds only when its securities are first sold in the primary market.

Secondary markets make it easier and quicker to sell these financial instruments to raise cash; that is, they make the financial instruments more liquid. They determine the price of the security that the issuing firm sells in the primary market. The investors that buy securities in the primary market will pay the issuing corporation no more than the price they think the secondary market will set for this security (Mishkin, 2004).

Secondary markets can be organized in two ways. One is to organize exchanges, where buyers and sellers of securities (or their agents or brokers) meet in one central location to conduct trades. The Johannesburg stock exchange is a good example of an organised exchange. The other method of organizing a secondary market is to have an over-the counter (OTC) market, in which dealers at different locations who have an inventory of securities stand ready to buy and sell securities “over the counter” to anyone who comes to them and is willing to accept their prices. As over-the-counter dealers are in computer contact and know the prices set by one another, the OTC market is very competitive and not very different from a market with an organized exchange (Mishkin, 2004).

2.2.3 Types of financial markets[2]

In addition to the primary and secondary markets, the financial markets can also be divided into the specific markets that make up the system. These markets include the money market,

[2] This refers to the four main financial markets in South Africa.

the bond market, the equity market and the foreign exchange market. These markets will be discussed in detail below.

2.2.3.1 Money market

The money market is usually defined as the market for short-term marketable debt instruments and short-term is an arbitrary one-year period (Faure, 2008). The money market is the domain of financial intermediaries like banks, insurance companies and pension funds (Faure, 2005). Banks are by far the most significant players in the money market. Money market investments are also called cash investments because of their short maturities. Money market securities are essentially issued by governments, financial institutions and large corporations. These instruments are very liquid and considered extraordinarily safe. Since they are extremely conservative, money market securities offer significantly lower returns than most other securities (Smith, 2006). There are several different instruments in the money market, offering different returns and different risks. These instruments include bankers' acceptances, negotiable certificates of deposit, treasury bills and commercial paper.

Commercial papers are mainly issued by banks and financial institutions, which is a promissory note that entitles note holder to get the face amount on a fixed date. Usually commercial papers are issued for short terms and their maturity period ranges from 1 to 270 days. As a result of the high risk involved, issuing companies offer higher interest rates to investors (King, 2009). A treasury bill (TB) is short-term debt obligation of the government payable on a certain future date. They are mainly held by banks - also held by insurance companies and money market funds, hedge funds, mutual funds and pension funds (Goodspeed, 2008).

A certificate of deposit is a certificate that is obtained by the investor after depositing an amount into banks or financial institution. Interest rate is fixed (the bigger the amount, the higher the interest rate will be) and a fixed maturity period as well. Bankers' Acceptance is basically a draft accepted and signed by some well known bank. The acceptance by that particular bank makes it an instrument used in money market as it carries very little risk. Once a time draft is approved (accepted) by some bank, the drawee can sell it in secondary market in case he/she is in need of immediate cash (of course at a price lesser than its face value) (King, 2009).

Central banks are key participants in the money market as this market is essential for the transmission of monetary policy. Central banks control the supply of reserves available to banks primarily through repurchase agreements or the outright purchase and sale of money market instruments such as treasury bills (Goodspeed, 2008). In summary, the money market encompasses the following markets: (1) markets in the securities of ultimate borrowers, (2) markets in the securities of financial intermediaries, (3) inter-bank market between private sector banks and (4) inter-bank market between the central bank and private sector banks (Faure, 2005:22).

2.2.3.2 The bond market

Bond market is an extension of money market. The bond market is a part of the long-term debt market: it is the market *marketable* long-term debt; i.e. debt that is issued in the form of tradable securities. Few borrowers are able to access this market, mainly because of the demands of the lenders in terms of credit risk, marketability (Faure, 2008). The bond is a contract between the borrower and the lender. The borrower could be a single person or a firm. Similarly the lender must be a single person or a financial institution such as a bank, an insurance company, or a pension fund. The borrower is the issuer of the bond; the lender is the owner of the bond. The contract that defines the bond requires the issuer of the bond to make a specified sequence of payment to the owner of the bond and to do things to protect the bond's owner against the possibility that the issuer might not make a promised payment on time (Bradfield, 2007: 20).

2.2.3.3 Equity market

The equity market is part of the capital market. Capital markets are markets in which institutions, corporations, companies and governments raise long-term funds to finance capital investments and expansion projects. This is the market where firms can raise capital and obtain long term funds (Goodspeed, 2008: 62). Equities, also known as shares or stock, represent a residual claim against the assets of a company after obligations to creditors and bondholders have been met. Equity market instruments include: ordinary shares, preference shares, depository receipts and exchange traded funds and the major participants in the market are limited public companies, investment banks, venture capitalists and different types of investors.

2.2.3.4 Foreign exchange market

The foreign exchange market is the financial market where currencies are bought and sold. The price at which they are traded is the exchange rate. The foreign exchange market plays a crucial role in facilitating crossborder trade, investment and financial transactions. The foreign exchange market is instrumental in facilitating international trade. The foreign exchange market is highly integrated globally and operates 24 hours a day – when one major market is closed another is open so trading can take place 24 hours a day moving from one centre to another. Currencies are traded over-the-counter (OTC) with trading taking place telephonically or electronically (Goodspeed, 2008: 41). Major participants in the foreign exchange markets include Commercial banks, Non-bank financial institutions, Firms and corporations and Central banks.

2.3 VOLATILITY TRANSMISSION

Volatility is the relative rate at which the price of a security moves up and down (Sharma, 2010). Volatility is found by calculating the deviation of daily change in price. If the price of a stock moves up and down rapidly over short time periods, it has high volatility. If the price almost never changes, it has low volatility. Volatility can also be used as nature of riskiness of a financial market.

Portfolio managers transfer funds from stocks into bonds when they expect stock market volatility to increase (Fleming, Kirby and Ostdiek, 1997). The risk reduction gained from funds transfer from one market to another, when market volatility is expected to increase, depends on the volatility linkages between the financial markets. Common market volatility arises from investor uncertainty induced from the initial shock event to the return of an asset.
Volatility transmission is also important for derivatives dealers, because when a dealer’s business cross more than one market, net volatility exposure depends on the cross-market correlations of volatility changes. Volatility linkages assist in setting regulatory policy, by influencing investment and risk management decisions. For instance banking regulators need to understand the nature of volatility linkages in order to appropriately assess capital adequacy. Volatility transmission is important for formulating and effectively implementing monetary policy.

The extent to which volatility is transmitted across markets could result in a large shock in one market destabilizing another market. It also helps policy-makers to estimate the depth and duration of cross-market impact and common market shocks, which assists in the implementation of timely and effective monetary policy. For financial stability, interest can be useful in determining different market price interrelationships, where the complexities signify a potential source of systemic financial instability (Hurditt, 2004).

Volatility can be used for various means, for example, how central banks adjust interest rates and reduce exchange rate volatility. It is also useful in understanding how an unexpected interest rate change could affect the conditional variance of the exchange rate (Brooks, 2008: 383). It can be applied to establish whether financial markets are efficient and for determining returns and volatility in a market, or between different markets.

2.4 NATURE OF LINKAGES BETWEEN FINANCIAL MARKETS

From an investment point of view the nature of linkages and volatility transmission has implications for securities pricing and transmission of risk across financial markets. These are interdependence or contagion and symmetry or asymmetry.

Contagion is defined as a significant increase in cross-market linkages after a crisis in one country. According to this definition, if two markets show a high degree of comovement during periods of stability, even if the markets continue to be highly correlated after a shock to one market, this may not constitute contagion. According to this definition, it is only contagion if cross-market comovement increases significantly after the shock or during the period of financial instability (Forbes and Rigobon, 2002). On the other hand according to (Collins and Biekpe, 2003) contagion is the state where correlations of asset prices increase during a period of turmoil. If there is an increase in correlation, it suggests that there is a strengthening of transmission mechanisms between the two countries in question. If there is no change in correlation over the period of turmoil, then there is interdependence but not contagion between the two countries. 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). According to Collins and Biekpe, (2003) interdependence can be seen as the correlation of equity markets during periods of financial stability.

There are various reasons for understanding whether financial markets are related in a ‘contagion’ or ‘interdependent’ nature. If financial markets are correlated in an interdependence manner international diversification would substantially increase expected returns and reduce portfolio risk. Conversely, 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 (Daly, 2003). This can also be considered in setting regulatory policy, given their influence on investment and risk management decisions. For example, banking regulators, like risk managers, need to understand the nature of volatility linkages in order to appropriately assess capital adequacy (Fleming *et al*, 1997).

Numerous markets are characterized by informational differences between buyers and sellers. The arrival of macroeconomic news in a stock market causes investors to adjust their portfolios depending on whether it’s good or bad news. 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.

2.5 THEORETICAL LINKAGES BETWEEN FINANCIAL MARKETS

Financial markets should be linked to one another because they are interrelated meaning that the shock in one market will affect the movements in another market either in a positive or negative way. This section discusses the possible theoretical channels through which the various financial markets are linked. Its organized as follows: Section 2.4.1 shows the linkages between the stock and foreign exchange market; Section 2.4.2 discusses the linkages between foreign exchange and money market; Section 2.4.3 discusses the linkages between money and bond market; Section 2.4.4 shows the relationship between the stock and money market followed by the link between foreign exchange and bond market shown in section 2.4.5; and finally Section 2.4.6 shows the linkages between the stock and bond market.

2.5.1 Interaction between stock and foreign exchange market

The relationship between stock prices and exchange rates has preoccupied the minds of economists since they both play important roles in influencing the development of a country's economy. In the recent years, because of increasing international diversification, cross-market return correlations, gradual abolishment of capital inflow barriers and foreign exchange restrictions or the adoption of more flexible exchange rate arrangements in emerging and transition countries, these two markets have become interdependent. Thus, understanding this relationship will help domestic as well as international investors for hedging and diversifying their portfolio.

A number of hypotheses support the existence of a causal relation between stock prices and exchange rates. For instance, 'goods market approaches' (Dornbusch and Fischer, 1980) suggest that changes in exchange rates affect the competitiveness of a firm as fluctuations in exchange rate affects the value of the earnings and cost of its funds as many companies borrow in foreign currencies to fund their operations and hence its stock price. A depreciation of the local currency makes exporting goods attractive and leads to an increase in foreign demand and hence revenue for the firm and its value would appreciate resulting in the appreciation of stock prices. On the other hand, an appreciation of the local currency decreases profits for an exporting firm because it leads to a decrease in foreign demand of its products and as a result the revenue for the firm decreases followed by a decrease in stock prices (Nath and Samanta, 2003).

An alternative explanation for the relation between exchange rates and stock prices can be provided through 'portfolio balance approaches' (Frankel, 1993), that stress the role of capital account transaction. A rising stock market would attract capital flows which increase the demand for domestic currency and cause exchange rate to appreciate (Tahir and Ghani, 2002). The reverse would happen in case of falling stock prices where the investors would try to sell their stocks to avoid further losses and would convert their money into foreign currency to move out of the country. There would be demand for foreign currency in exchange of local currency and it would lead depreciation of local currency. Thus, rising (declining) stock prices would lead to an appreciation (depreciation) in exchange rates (Nath and Samanta, 2003)

Understanding the causal relationship in foreign exchange and stock exchange markets is of great importance to policy makers. Suppose, we know that the exchange rates affects the stock prices, policy-makers may fortify the economy's stock market by enhancing the exchange rate market conditions, for instance, reducing excessive fluctuations of exchange rates. Conversely, if stock prices are found to affect exchange rates, then exchange rate conditions may be strengthen via improving the stock markets' fundamentals (Hussain and Liew, 2004).

2.5.2 Interaction between foreign exchange and money market

This part explores the link between foreign exchange markets and money markets. The section will start by looking at the link between the money market and the foreign exchange markets in the short run and then explore the interaction of the two markets in the long run.

Suppose the South African Reserve Bank (SARB) increases its money supply temporarily, this leads to a reduction in the local interest rate. The reduction in the local currency interest rate reduces the rate of return of local currency deposits relative to foreign currency deposits, thus inducing investors to sell their local currency and buy foreign currency. As a result, the local currency depreciates. Furthermore, suppose the foreign Central Bank increases its money supply temporarily. The increase causes the foreign interest rate to drop, thus reducing the expected rate of return of foreign deposits to decrease relative to local deposits. As a result, investors decide to sell their foreign currency for local currency, thus leading to an appreciation of the local currency.

On the other hand, a permanent increase in a country's money supply causes a proportional increase in the price level and a proportional long-run depreciation of its currency against foreign currencies. As a result they tend to be a negative relationship between the money market and foreign exchange market.

2.5.3 Interaction between the money market and bond market

This section investigates the link between the money and bond market. The relationship between money and bond market is often derived in two steps that is by looking at the relationship between the interest rate and money market followed by the relationship between interest rates and the bond market. According to the liquidity effect theory, an increase in the

supply of money creates an excess supply of money at existing income, interest rate and price levels. Money demand is a decreasing function of nominal interest rates, because the interest rate is the opportunity cost of holding cash. An increase in the supply of money must cause interest rates to decrease in order to keep the money market in equilibrium (Alatiqi and Fazel, 2008). According to Little (2009) bond prices move inversely to interest rates. In this case as interest rate decreases the bond prices will tend to increase. As a result of the above information there is a positive relationship between the money market and bond market.
The above situation is true only for bonds that have already been issued and are now traded in the open market. For instance, if you want to sell a bond that has a lower interest rate level than the one that is currently experienced you should decrease the face value of the bond. However, if the opposite conditions are experienced (i.e. the bond's interest rate is higher than the current levels on the open market), you will be able to sell the bond at a premium that is greater than the face value (stock market investors, 2008).

2.5.4 Interaction between money market and the stock market

A positive causal relation from money supply to stock prices is frequently hypothesized by some financial analysts. The hypothesized causal relation from money supply to stock prices is often derived in two steps: an assumed negative causal relation from money supply to interest rates, followed by an assumed negative causal relation from interest rates to stock prices (Alatiqi and Fazel, 2008).

The negative causal relation from money supply to interest rates is often based on the short-term liquidity effect. An increase in the supply of money creates an excess supply of money at existing income, interest rate and price levels. An increase in money supply must cause interest rates to decrease in order to keep the money market in equilibrium. A decrease in interest rates leads to lower borrowing costs for firms, higher future profits and thus higher stock prices. It is also argued that lower interest rates prompt investors to move money from the bond market to the equity market (Alatiqi and Fazel, 2008).

As a result an increase in the supply of money in the money market is a driving factor for the increase in the stock prices and the reverse is true.

2.5.5 Interaction between foreign exchange market and bond market

This part explores the theoretical link between foreign exchange markets and bond markets. There are three economic mechanisms that could connect currency crashes to bond market crashes. First, according to the "Fisher effect" or inflation expectations channel, exchange rate depreciations may be expected to push up domestic inflation through higher prices for imported goods and services and as a result investors in the bond market are likely to demand a higher nominal rate of return to compensate for expected inflation. Second, the "monetary reaction" channel states that investors may expect that the monetary authority will raise short-term interest rates even more than the increase in inflation in order to prevent higher inflation from becoming entrenched (Gagnon, 2005).

Finally the "risk premium" channel says that the currency crash could cause investors to demand a higher risk premium on bonds because of heightened uncertainty about future inflation, future real interest rates, or even the possibility of a future default. These higher risk premiums are in the form of higher interest rates which will later affect the bond market through the reduction in bond prices (Gagnon, 2005). Therefore, there is a negative relationship between the foreign exchange and bond market.

2.5.6 The interaction between the bond market and stock market

It is of great essence to know the relationship between stocks and bonds. A stock represents a piece of a company owned by an investor and a bond represents a loan to a company or to a government agency for which the lender receives interest payments.

In this case we are going to look at the relationship between the bond market and stock market through the movements in interest rates. In this argument, monetary policy shocks are used as a proxy for interest rate shocks. An expansionary monetary policy lowers interest rates and makes all debt instruments (bonds, demand deposits, treasury bills) less attractive because they become expensive relative to stocks. A fall in interest rates will therefore increase the demand for stocks, pushing up the price of stocks. Alternatively, a contractionary policy (an increase in interest rates) leads to an increase the demand for debt securities (bonds) and a fall in the demand for stocks and stock prices. The relationship between the stock and bond market arises from this trade off resulting in an inverse relationship between the two markets (Alatiqi and Fazel, 2008).

2.6 EMPIRICAL LITERATURE

Numerous studies have been carried out on the relationship and volatility transmission between the money, bond, stock and foreign exchange market. Various studies have documented common occurrence of financial markets volatility transmission. While literature is available on the relationship between the financial markets, most of the empirical studies that are available are based on advanced countries, with developing countries receiving very little attention. For instance, Yang and Doong (2004) examined the relationship between volatility of stock markets and foreign exchange market for the G-7 countries and Rigobon and Sack (2003) examined volatility spillovers across US markets. In general, empirical evidence on market relationships is inconclusive. While some authors find significant relationships, others found weak and insignificant links, see (Solnik, 1987; Nieh and Lee, 2001).

This reviews the empirical literature on the relationship between the money, bond, stock and foreign exchange market and is organised as follows: Section 2.5.1 discusses empirical evidence on the linkages between stock and foreign exchange market; Section 2.5.2 discusses the linkages between the bond and stock market. The above linkages have been analysed separately because most empirical studies have focused on those two linkages mentioned above and their implication to the economy. Section 2.5.3 discusses other relevant literature on volatility transmission between financial markets basing mainly on those authors who have focused on the interaction between more than two markets.

2.6.1 Stock market and foreign exchange market.

Several theoretical models have analysed the link between stock markets and currency markets. The lead-lag short-run dynamic and long-run equilibrium relationships between these two financial assets can be used as a foresight instrument for investors and speculators for possible arbitrages. The empirical analysis for the relationships between stock market and foreign exchange market can be found in various literatures, but the results are fairly mixed as to the significance and the direction of influences between stock prices and exchange rates.

The asset market approach to exchange rate determination (Branson, 1983; Frankel, 1983) states that causality will run from stock prices to exchange rate changes as expectations of financial asset price movements affect the dynamics of exchange rates. On the other hand, the goods market approach suggests causality runs in the opposite direction, from exchange rates to stock prices (Mundell, 1963, 1964; Dornbusch and Fisher, 1980). Hatemi-J and Irandoust (2002) studied a possible causal relation between exchange rates and stock prices in Sweden and they found that Granger causality is unidirectional from stock prices to effective exchange rates. Alternatively, Huzaimi and Liew (2004:16) found evidence of bi-directional causality between exchange rates and stock prices in Malaysia.

Aggarwal (1981), considered the relationship between stock prices and exchange rate using monthly U.S. stock price data and the effective exchange rate for the period 1974 to 1978. He found that stock prices and exchange rates are positively correlated with a stronger relationship in the short run than in the long run. However Soenen and Hennigar (1988), employing monthly data on the same variables for the same country, for the period 1980 to 1986, found a strong negative relationship.

Solnik (1987) employed OLS regression analysis on monthly and quarterly data from 1973 to 1983 for eight industrialized countries. He found a negative relationship between real domestic stock returns and real exchange rate movements. Though, for monthly data over 1979-83, he found a weak but positive relation between the two variables. In 1979 the U.S. and U.K. moved to a strict monetary policy focusing on monetary aggregates rather than interest rate levels which induced short-run movements in both the real interest rate and exchange rate. As a result a weak positive relation was found between real stock-return differentials and changes in the real exchange rate, this would support the idea that anticipated real growth has a positive influence on the exchange rate.

Nieh and Lee (2001) examined the relationship between stock prices and exchange rates for G-7 countries using the daily closing stock market indices and foreign exchange rates for the period from October 1, 1993 to February 15, 1996. The study employed both the EG two steps and the Johansen maximum likelihood cointegration tests. The VECM was further applied to assess both the short-run intertemporal comovement between these two financial variables and their long-run equilibrium relationship. They find that there is no long-run equilibrium relationship between stock prices and exchange rates for each G-7 countries.

While one day's short-run significant relationship has been found in certain G-7 countries, there is no significant correlation in the United States. These results might be explained by each country's differences in economic stage, government policy, expectation pattern, etc. The differences in the level of internationalization and liberalization and the degree of the capital control from country to country can also be crucial factors, which result in different predicting power of the two financial assets. Moreover, the insignificant long-run outlook (no cointegration) for each of the G-7 countries implies that these two financial assets share no common trends in their economy system and hence they will move apart in the long run.

The article by Mishra, (2004) examined whether stock and foreign exchange markets are related in India. The study used Granger's Causality test and Vector Auto Regression technique on monthly stock return, exchange rate, interest rate and demand for money for the period April 1992 to March 2002. The major findings of the study were that there exists a unidirectional causality between the exchange rate and interest rate and between the exchange rate return and the stock market. They also concluded that there is no Granger's causality between the exchange rate return and stock return.

A study by Pan *et al.* (2007) examined dynamic linkages between exchange rates and stock prices for seven East Asian countries, including Hong Kong, Japan, Korea, Malaysia, Singapore, Taiwan and Thailand, for the period January 1988 to October 1998. The study used Granger causality test and vector autoregressive analysis on daily stock market indexes and exchange rates (expressed in local currency per U.S. dollar) for the period January 1988 to October 1998. The result of study showed that a bidirectional causal relation for Hong Kong before the 1997 Asian crises. Also, they found a unidirectional causal relation from exchange rates and stock prices for Japan, Malaysia and Thailand and from stock prices to exchange rate for Korea and Singapore. During the Asian crises, there was only a causal relation from exchange rates to stock prices for all countries except Malaysia. Linkages could vary across economies with respect to exchange rate regimes, the trade size, the degree of capital control and the size of equity market.

A study by Adjasi *et al.,* (2008) looked at the relationship between stock market volatility and foreign exchange market volatility and determined whether movements in exchange rates have an effect on stock market in Ghana from January 1995 to June 2005. The Exponential Generalised Autoregressive Conditional Heteroskedascity (EGARCH) model was used and the study found that there is negative relationship between exchange rate volatility and stock market returns, depreciation in the local currency leads to an increase in stock market returns in the long run. Where as in the short run it reduces stock market returns. It was also revealed that an increase (decrease) in trade deficit and expectation in future rise in trade deficit will decrease (increase) stock market volatility. Finally, they found that there is the presence of leverage effect and volatility shocks in stock returns on the Ghana Stock Exchange.

In summary, most results indicate that the stock market and the foreign exchange market are related. These markets are either positively or negatively related. Aggarwal (1981) and Solnik (1987) for the period 1979-83 found that stock prices and exchange rate are positively correlated. On the other hand, the studies of Soenen and Hennigar (1988); Solnik (1987) for the period 1973-79 and Adjasi *et al.*, (2008) among others found that stock prices and exchange rate are negatively correlated. Other studies find that there is no long-run equilibrium relationship between stock prices and exchange rates (Nieh and Lee, 2001).

2.6.2 Bond market and stock market

The investigation of the correlation between returns on the stock and bond markets is one of the most important topics in analysing financial return series because the empirical correlations between different assets provide inputs for guiding asset allocation, portfolio selection and risk management. There are good reasons for the many studies that analyse these two asset returns, since these two types of assets constitute the major categories in the daily investment menu. The study of the stock-bond correlation has been popularized lately by the so-called “Fed model”. The Fed model is based on the idea that investors view stocks and bonds as competing assets in their portfolio. It states that whenever a yield differential is created, investors will reallocate assets from lower return investments to higher return ones.

Lim *et al.*, (1998) investigated the interrelationships between international bond and international stock markets over the period November 1988 through December 1993. The analysis employs the Morgan Stanley capital international world index as a proxy for international equity markets and the Salomon Brothers world bond index as a proxy for international bond markets. Cointegration and granger causality methodologies were used to determine the relationship between international bond markets and international stock markets. The study found that bidirectional causality exists between stock market returns and bond market returns.

A paper by Li., (2002) examined the correlation between stock and bond returns for G7 countries (the U.S., the U.K., France, Germany, Japan, Canada and Italy). Using data from 1958 to 2001 the paper documents large variations in the stock-bond correlation. They found that the correlation was high in the early 1960s to mid 1990s. They also found that the correlation between stock and bond prices was low during the period after 1990. A simple model which endogenously derives stock and bond returns reveals that the uncertainty about expected inflation and the real interest rate is likely to increase the comovement between stock and bond returns. The correlation was high in the 1970s due to an oil crisis and a subsequent economic stagflation in major industrial countries, which caused high and persistent inflation expectations for over a decade. Investors' concern for inflation strongly affected the valuation of financial assets during this period and resulted in high comovement between stock and bond returns. The sharp decline in stock-bond correlations in the 1990s can be partially attributed to the lower inflation risk during this period.

Fang *et al*,(2006) attempts to investigate the transmission of market-wide volatility between the equity markets and bond markets of Japan and the US. To measure the volatility transmission, the BEKK (Baba, Engle, Kraft and Kroner, 1990) method, a decomposition approach of the multivariate GARCH (1,1) model, is used. The study analysed the data from 1/1/1988 to 2/13/2004. The paper established some evidence of volatility transmissions of the equity and bond markets between Japan and the U.S. the volatility of stock market has a strong influence on the volatility of the bond market. However, the causal effect is contemporaneous in U.S, while in Japan, they observed the lagged causal effect. The volatility transmission between these assets indicates that the international diversification of bonds is not prevalent.

The paper by Chiang and Li., (2009) analysed the correlation of returns between the U.S. stock and bond markets, using rolling regression method, BEKK GARCH model and asymmetric dynamic conditional correlation (ADCC) GARCH model. The sample period (1996-2008) of this paper observed an average negative stock-bond correlation although it is very close to zero.

In a nutshell, the above results show that all types of correlation coefficient depend on the sample periods under investigation. All types of correlation coefficients are time-varying and very volatile, swinging between positive and negative. It is therefore inappropriate to claim the sign of the stock-bond return correlation without indication of the sample period. As a result the literature analysed above give us different results ranging from negative to positive stock-bond correlation depending on the period being investigated and the type model being used in the study.

2.6.3 Other Relevant literature

This following part will focus on the empirical evidence basing on the authors that have looked at the volatility transmission among more than 2 financial markets. It has been observed that many authors have looked at the interaction between two markets for instance foreign exchange and stock market neglecting the effects of the other financial markets. Few authors have looked at the volatility transmission of three or all four financial markets at once.

Fleming, Kirby and Ostdiek (1997) investigated the nature of volatility linkages in the stock, bond and money markets in the U.S. To measure these linkages, they estimated a stochastic volatility representation of the trading model using general methods of moments (GMM). The data used consists of daily closing prices for each market, for the period 3 January 1983 to 31 August 1995. They found that the volatility linkages between the three markets are indeed strong and have become stronger since the 1987 stock market crash. Fleming et al (1997) also anticipated common information and information spillover to play an important role. The trading model examined the degree of information spillover in that, information spillover is complete in frictionless markets, making volatility changes across markets perfectly correlated, which deteriorates when transactions costs, institutional constraints and other practical considerations are accounted for, reducing cross-market hedging impact.

In a similar study, Hurditt (2004) studied volatility transmission across Jamaican financial markets. Hurditt (2004) applied multivariate GARCH method to returns on the Jamaican bond, foreign exchange and stock markets. The empirical model was used to estimate coefficients showing common market impact and cross-market volatility spillovers. The market liquidity changes, in terms of bond maturities were considered in computing volatility spillovers. The paper used modelled variance series as inputs in a simple vector autoregressive (VAR) model to produce ten-day volatility impulse responses, to indicate a market asset return variance level and its impact on lagged variances from returns in the same market and the other two markets. In order to avoid the unrealistic assumptions on the variance-covariance matrix and the non-positive variance-covariance matrix certainty, applied Engle and Kroner (1995)'s proposed BEKK model -named after Baba, Engle, Kraft and Kroner (1991) and concluded that there is presence of high levels of common market returns volatility relative to cross-market spillovers, within the Jamaican financial system.

Foreign exchange markets displayed the most distinct common market volatility spillovers, followed by the stock market and having strong common market spillover, relative to the bond market indicates uncertainty force, as a usual feature of risky markets. He also concluded that cross-market spillover effects, due to changes in the liquidity conditions have smaller influence on spillovers to the bond market than for the foreign exchange and the stock markets. Changes in liquidity have no significant impact on volatility spillover durations, implying that monetary policy is successful in controlling volatility impulse impact within and between liquid markets.

A paper by Ehrmann *et al.*, (2005) analysed the degree of financial transmission between money, bond and equity markets and exchange rates within and between the United States and the euro area in the period 1989-2004. This paper looks at the domestic transmission within the USA and the international transmission between the USA and the euro area. The results stress the importance of domestic as well as international spillovers. Asset prices are found to react strongest to other domestic asset prices. Although the strongest international transmission of shocks takes place within asset classes, they found evidence that international cross-market spillovers are significant, both statistically as well as economically. For instance, shocks to US short-term interest rates exert a substantial influence on euro area bond yields and equity markets.

Abdul and McAleer (2008) forecasts conditional correlations between three classes of international financial assets, namely stock, bond and foreign exchange. They considered two countries, namely Australia and New Zealand. Forecasting was conducted using three multivariate GARCH models, namely the constant conditional correlation (CCC) model of Bollerslev (1990), the VARMA-AGARCH of McAleer *et al* (2000) and the VARMA-

GARCH model of Ling and McAleer (2003). Both VARMA-AGARCH and VARMA-GARCH models incorporated volatility spillovers, with VARMA-AGARCH also considering asymmetric effects of negative and positive shock on the conditional variance. The paper found the evidence of volatility spillovers and asymmetric effect of negative and positive shock on the conditional variance in most pairs of series. They found positive correlation for the pairs of bond–bond, stock–stock, bond–stock and foreign exchange–foreign exchange and negative for the pairs of bond-foreign exchange and stock-foreign exchange. It was concluded that Australian bond and New Zealand bond had the highest correlation, with the maximum of 0.8, while the rest are low, average about 0.5. The low correlations open the possibility of potential gain from diversifying portfolio among those assets.

SHIKWAMBANA, (2007) examined volatility in the stock, money and foreign exchange markets in South Africa. The study experimented with various volatility models that include the GARCH, TARCH and EGARCH. Volatility in the financial markets was found to be highly persistent and in the case of exchange rates, volatility was also characterised by an increasing trend. The links between the stock market and the money market were found to be particularly strong. The foreign exchange market displayed strong links to both the stock market and the money market. An examination of volatility trends revealed a decreasing trend in both the stock market and the money market, while volatility in the foreign exchange market was found to be increasing.

2.7 CONCLUSION

This chapter explored diverse issues regarding the linkages of stock markets. It started by highlighting the importance of understanding the linkages of stock markets, both from a policymaking and an investment analysis point of view. The nature of linkages between financial markets was then analyzed to provide a theoretical backing to the empirical literature. The empirical literature regarding the linkages of stock markets was then reviewed.

The empirical literature discussed the links between the financial markets focusing mainly on those studies that examined interaction of market volatilities. In the first part of the empirical literature studies which looked at any two financial markets were reviewed. Empirical studies support the hypothesis of co-movement between stock prices and exchange rates, although the results are mixed. Empirical literature also found significant volatility spillovers from the foreign exchange market to the stock market. With regard to the bond market and the stock market variability, empirical studies found bidirectional causality exists between stock market returns and bond market returns (Lim et al., 1998). In addition to, the empirical evidence backed the theoretical view in that they found a negative relationship between the bond and stock (Chiang and Li., 2009). Getting on to the studies which looked at the combined relationship between more than two financial markets, they found evidence of volatility spillover between the financial markets. The correlations ranged from negative to positive depending on the markets being focused on, for instance the bond-foreign exchange correlation was negative (Hakim and McAleer, 2008). The low correlations open the possibility of potential gain from diversifying portfolio among those assets.

The South African financial market has undergone a number of institutional changes which have not been considered in any previous studies. These changes might be the key effects to the size and nature of volatility transmission between South African financial markets. As evident from the review, existing relevant studies for Africa focus on either return linkages between two markets or at most three financial markets within the economy. Most studies eliminated the effects of the foreign exchange market on the stock, bond and money market and no study has looked at the volatility transmission between all the 4 financial markets in South Africa. There is need for a study which looks at the interaction of all the 4 markets at the same time. Thus this study attempts to fill these gaps.

The next chapter discusses the trends and behaviour of the South African financial markets. In this chapter, volatilities trends are analysed in order to identify the high and low volatility periods.

CHAPTER 3

LINKAGES BETWEEN SOUTH AFRICAN FINANCIAL MARKETS

3.1 INTRODUCTION

The previous chapter has highlighted the theoretical linkages between the South African financial markets, for instance the 'goods market approaches' (Dornbusch and Fischer, 1980) suggests that a negative relationship exists between the stock and foreign exchange market whereas, the 'portfolio balance approaches' (Frankel, 1993), stresses the role of capital account transaction which leads to a positive relationship between the stock and the foreign exchange market. Given the theoretical approaches studied in the previous chapter, this chapter studies the actual data of the South African financial markets from the period 1995 to 2009 in comparison to the given theoretical approaches.

The chapter is organised as follows: section 3.1 discusses the relationship between the financial markets basing on the actual data recorded from Thompson Data stream; section 3.2 shows a comparative analysis of the 4 financial markets and finally section 3.3 concludes the chapter.

3.2 RELATIOSHIP BETWEEN THE SOUTH AFRICAN FINANCIAL MARKETS

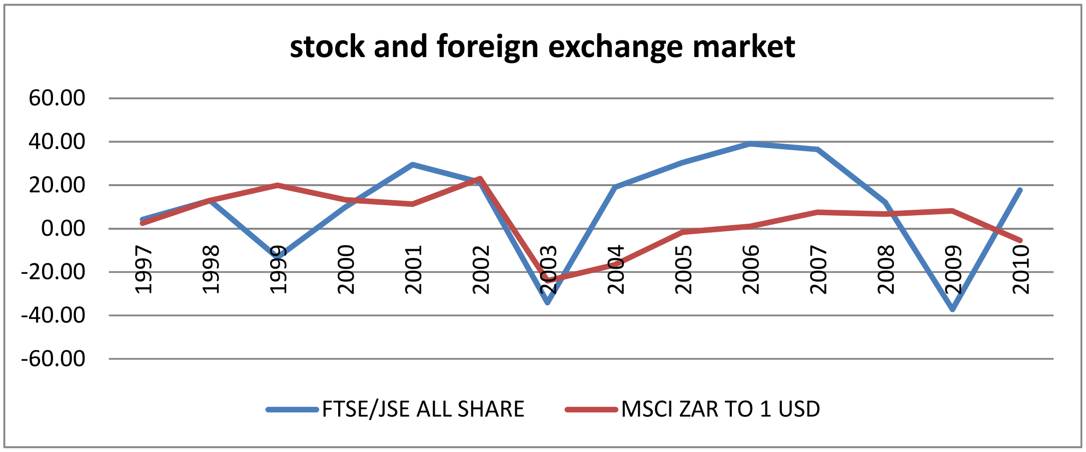
This section will discuss the relationship between the markets basing on the actual data and compare it to theory. There are some situations where the theoretical review contradicts the actual market movements and this might be a result of unexpected market shocks or any other relevant reasons.

3.2.1 Relationship between stock and foreign exchange market

Relationship between stock returns and exchange rates has been examined by using monthly data form year 1997 to March 2010. Previous studies, which have examined the relationship between stock and foreign exchange markets found different results concerning the links between the two markets. For example, Aggarwal (1981) finds that there is a positive relationship between the stock and the foreign exchange market while on the other hand

Soenen and Hennigar (1988) found a significantly negative relationship. The graph below shows how the two markets are interlinked in South Africa from the period 1995 to 2010.

Figure 3.1: Stock and foreign exchange market



Source: Thompson DataStream (2010)

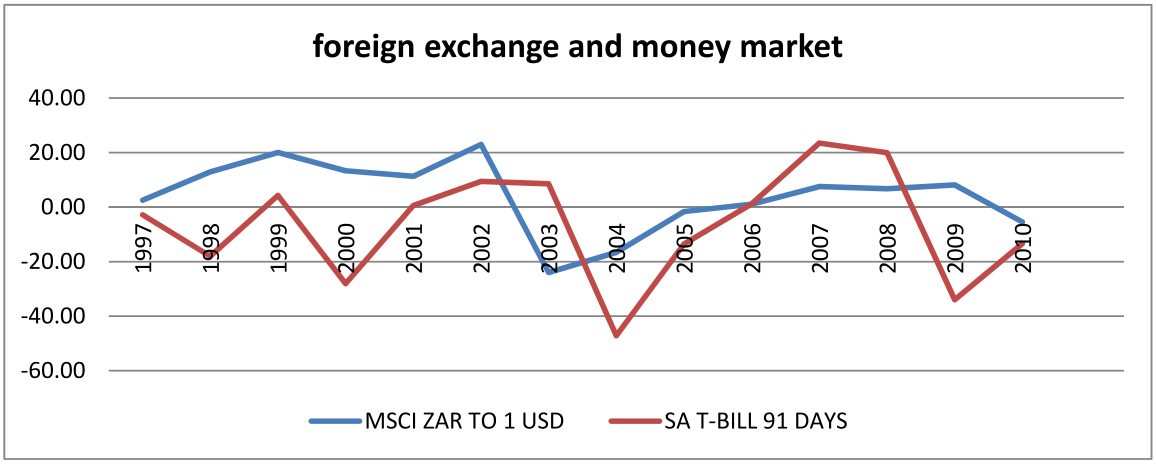
Basing on theory 'goods market approaches' (Dornbusch and Fischer, 1980) suggest that there is a negative relationship between the two markets while on the other hand the 'portfolio balance approaches' (Frankel, 1993), that stress that there is a positive relationship. From 1997 to 1998 the portfolio balance approach is proven to be true since both the stock and the foreign exchange markets are increasing. Considering the same period 1997 to 1998 the results shown on the graph might be a bit biased due to the effects of the Asian economic crisis. This crisis stretched to the developing countries (South Africa) through increases in food prices, slow growth, high risks and changes in the patterns and terms of trade (The World Bank, 1998).

From the period 1998 to 2002 there has been a negative relationship between the two markets thus backing the 'goods market approaches' (Dornbusch and Fischer, 1980). In 2001 to 2002 there has been a rapid decrease in stock market and an increase in the foreign exchange market; this might be due to the September 11 effect since most of South Africa's trading partners were affected. From 2006 up to the present, there was negative relationship again between the two markets although the stock market went to its lowest in 2008 to 2009 period. This was because of the global recession which hit the world during that period. Overall the graph above shows a negative relationship between the stock and the foreign exchange market for the greater part of the time and as a result the theoretical view especially by (Dornbusch and Fischer, 1980) is in line with real market movements.

3.2.2 Relationship between foreign exchange and money market

Figure 3.2 shows the relationship between exchange rates and the money market using monthly data for year 1997 to March 2010. Existing studies have come up with different results concerning the linkages between these two markets.

Figure Error! No text of specified style in document.**2: Foreign exchange and money market**



Source: Thompson DataStream (2010)

The discussion in the previous chapter states that there is a negative relationship between foreign exchange and money market. Basing on the graph above the markets movement from period 1998 to 2000 contradicts with theory in that there has been a positive relationship between the two markets and this might be due to the effects of the Asian crisis which took place in 1998. Another positive relationship is observed from 2004 to 2007 and this might be due to economic shocks within that period.

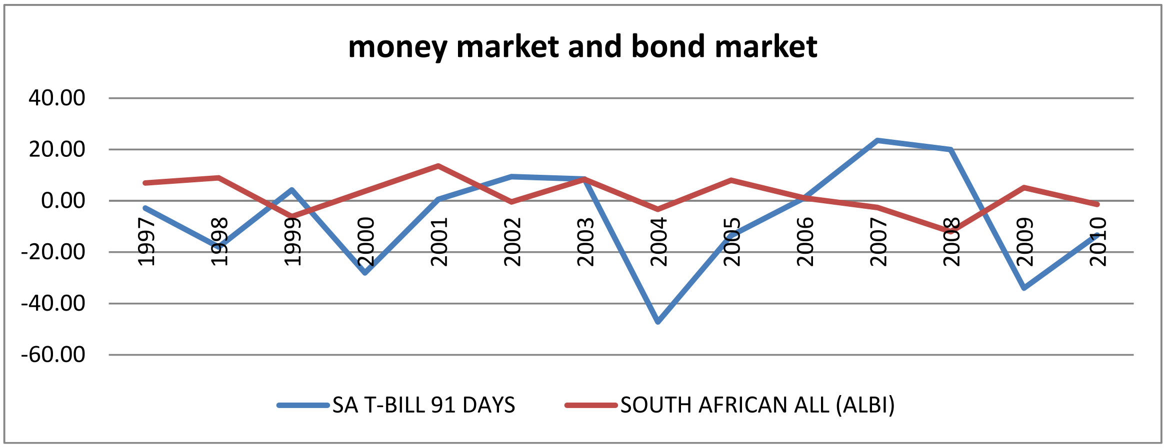
Generally, the graph above shows that there has been a negative relationship between the foreign exchange and the stock market from the period 1997 to 2010. As a result, the theoretical review is in line with reality and this is evidenced by the graph above which used the statistical data for South African markets.

3.2.3 Relationship between the money market and bond market

This section investigates whether the actual relationship between money and the bond market is in line with the theoretical view basing on the South African data. The data from 1997 to

2010 was used to graphically analyse the relationship between the money and the bond market and this is given by the graph below.

Figure 3.3: Money market and bond market



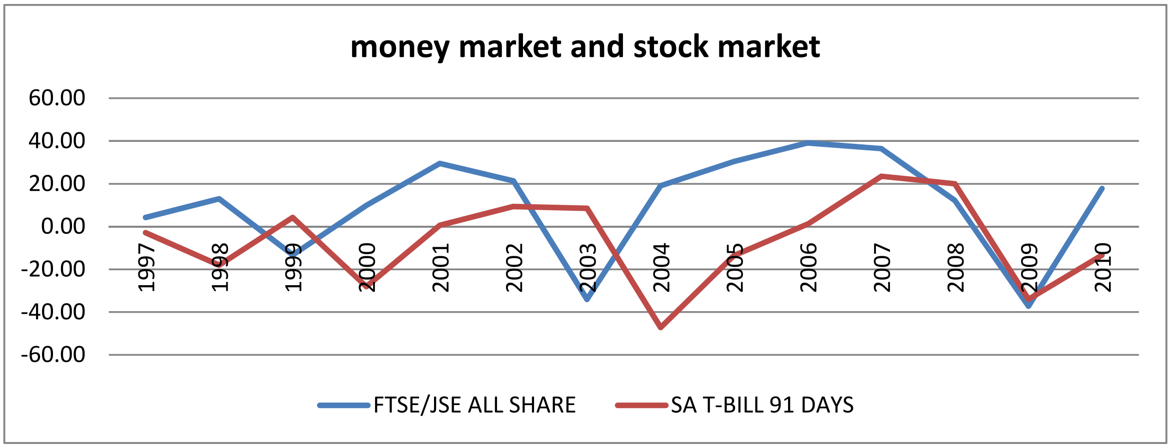
Source: Thompson DataStream (2010)

The relationship between the money and bond market is derived through interest rates and this is in two steps that is by looking at the relationship between the interest rate and money market followed by the relationship between interest rates and the bond market. The previous chapter shows that there is a positive relationship between money and bond market. Now looking at the graph above we observe that on average there is a negative relationship between the money and the bond market. Basing on the same results the theoretical view tends to differ from reality in the case of South Africa's bond and money market. The possible reasons for this might be that South Africa financial markets are still unstable as it is still in its developing stages.

3.2.4 Relationship between the money market and stock market

The relationship between these two markets for 1997 to 2010 is shown in Figure 3.4 below. Some investing experts track change in money market as a potentially important indicator of future stock market behaviour. A positive causal relation from money supply to stock prices is commonly put forward by some financial analysts. The basis of this assertion is an assumed negative causal relation from money supply to interest rates and a negative causal relation from interest rates to stock prices. On the other hand a paper by Alatiqi and Fazel (2008) argued that there is no significant long-term causal relation from money market to stock prices. The graph below shows the relationship between the money and stock market basing on South African data.

Figure 3.4: Money market and stock market



Source: Thompson DataStream (2010)

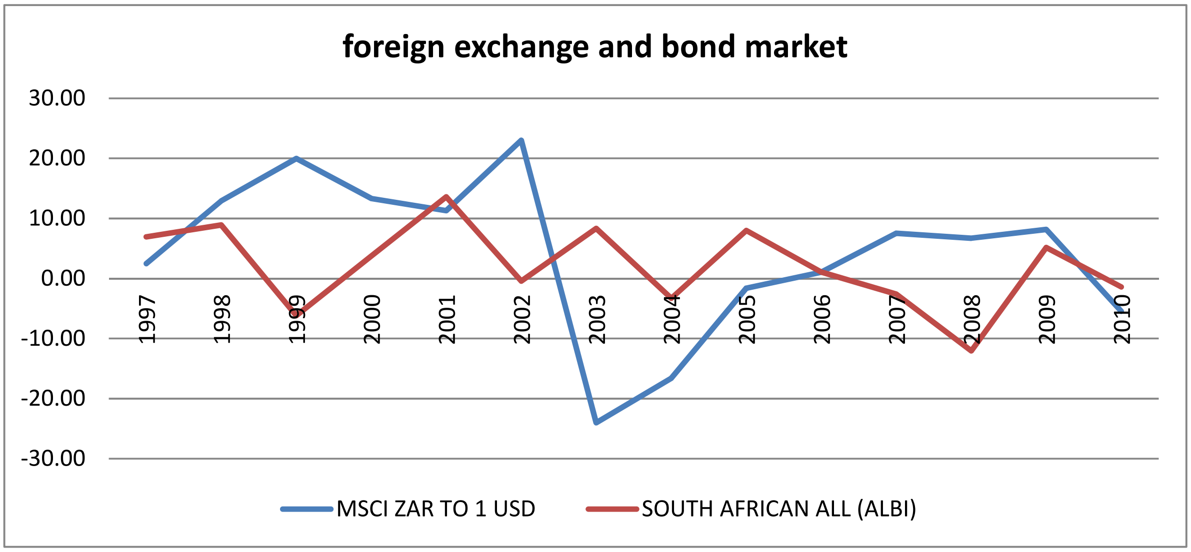
The graph above clearly shows that there is a positive relationship between the markets especially from the period 2000 to 2010. Before year 2000 the graph showed a negative relationship between the money market and the stock market and this might be because the South African financial markets were still at their earlier stages soon after independence.

In general, considering the markets in question it is concluded that the observed markets movements are in line with the theoretical view pertaining the markets.

3.2.5 Relationship between foreign exchange market and bond market

The previous chapter looked at the theoretical link between foreign exchange markets and bond markets. A study by (Gagnon, 2005) states that there is a negative relationship between the foreign exchange and the bond market. In this case we are going to look at the period from 1997 up to 2010 to see if the actual markets behaviour is in line with the theoretical view given in the previous chapter. The graph below shows the relationship between the foreign exchange market and the bond market in the case of South Africa.

Figure 3.5: Foreign exchange and bond market



Source: Thompson DataStream (2010)

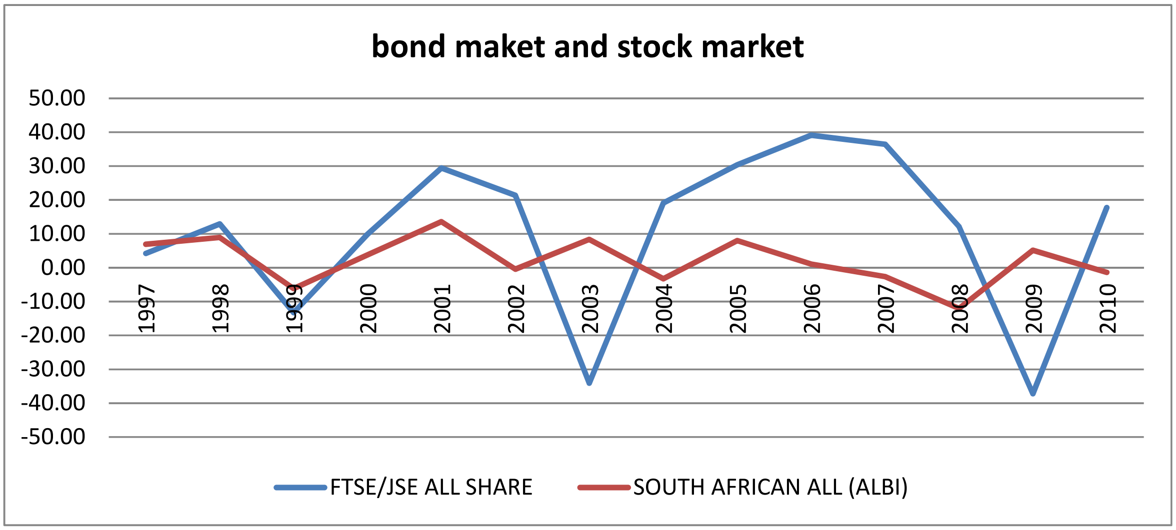
Looking at the graph above it is observed that from the period 1997 to 2008 there has been a negative relationship between the foreign exchange and the bond market. This shows that the movements between these two markets entirely support the theoretical review as discussed in the previous chapter.

From 2008 to 2010 the graph shows a positive relationship between the two markets opposing the theoretical view. This might be due to the impacts of the global recession which took place from 2008 up to the end of 2009. On average the graph shows the negative relationship between foreign exchange and the bond market.

3.2.6 Relationship between the bond market and stock market

Understanding stock and bond market relationship has important practical implications in several areas. First, asset allocation between stocks and bonds is one of the fundamental decisions that portfolio managers and individual investors must make. Second, understanding volatility linkages and conditional correlations also has a role in risk management and derivative valuation. Existing literature doesn't give consistent conclusion on the relationship between these two markets. A paper by (Stivers and Sun, 2002) concluded that stock and bond returns tend to exhibit little relation or even a negative relation during periods of high stock market uncertainty. On the other hand (Kwan, 1996) finds that individual stock and bond prices tend to move in the same direction. The graph below shows the relationship between the bond market and the stock market for South Africa from the period 1997 to 2010.

Figure Error! No text of specified style in document.**3.6: Bond market and stock market**



Source: Thompson DataStream (2010)

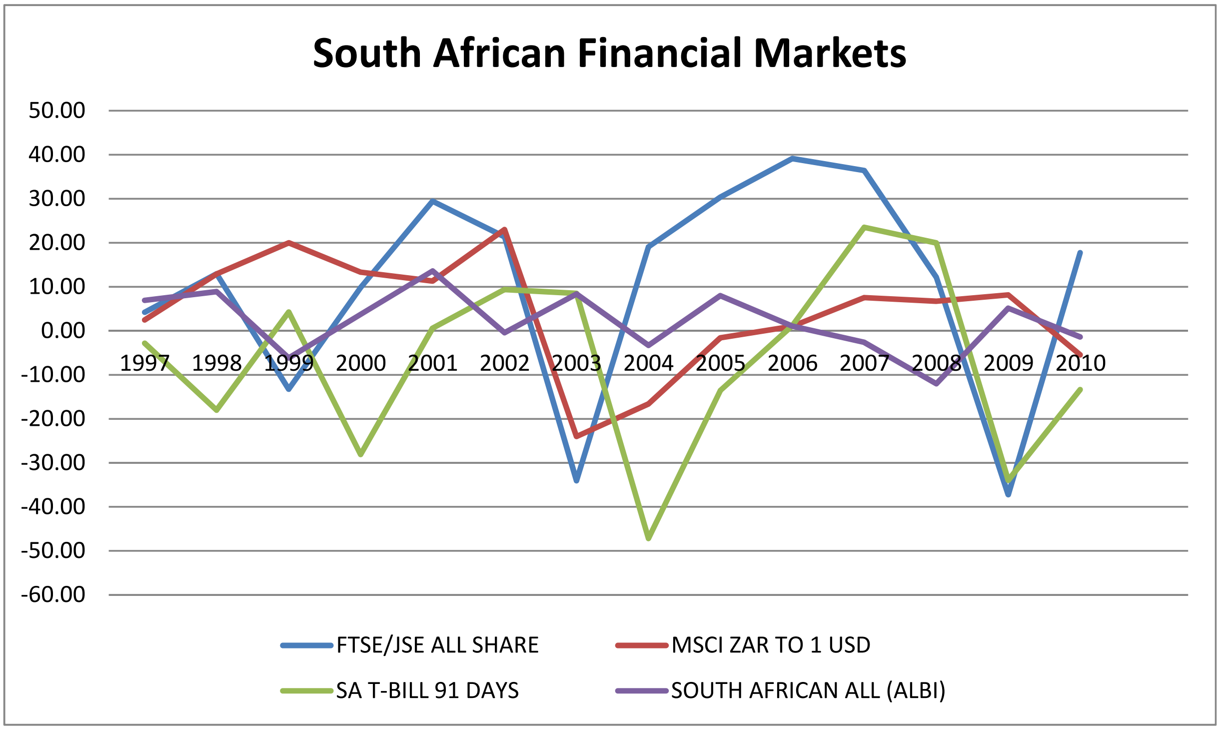
Based on the graph above, it is observed that for the case of South Africa, the bond market and the stock market are positively related for the greater part of the study period that is from 1997 to 2002 and 2004 to 2008. The graph shows a negative relationship in 2003 and from 2008 to 2010. Overall, is observed that the bond and stock market in South Africa are positively related and this is backed by a study done by (Kwan, 1996) which states that individual stock and bond prices tend to move in the same direction.

3.3 COMPARATIVE ANALYSIS OF THE MARKETS

This section analyses the behaviour of all the 4 South African financial markets basing especially those periods where the markets had large breaks. These markets are said to be interrelated meaning that the shock in one market will affect the movements in another market either in a positive or negative way.

Figure 3.6 below shows the movements of the 4 South African financial markets collectively from the period 1997 to 2010. Month returns were computed from each market index by forming log differences of the data for each market.

Figure 3.7: Long term performance of the South African financial markets



Source: Thompson data stream

In this case we are going to look at periods where the markets had large breaks within their movements and the effects of the Asian and Sub-prime crisis on the market movements. To start with, it is observed from the above graph that in the year 1999 there is a sharp turning point for all the markets in question. This might be the effect of the Asian crisis which took place from the 1997 to 1998. The Asian crisis affected South Africa though a decline in world commodity prices that has been compounded by weakened demand in Asia.

Looking at the period 2006 to 2008, All share and exchange rate increased (depreciation of local currency) unlike the All bond and the SA T-Bill which showed a sharp decrease. This might be possible considering that from the late 2007 up to the late 2008 the economy was in recession. The main effect was on investment, industrial production was badly affected as investors avoided investing in companies that might suffer losses during recession and this is evidenced by the decline in the stock market from the period 2008 to 2009. The graph above also shows that the market relationships during crisis differ from the relationship during good period since large breaks are observed during the period of crisis. In other words, the markets showed high volatility during the times of crisis.

3.4 CONCLUSION

This chapter discussed the relationship between the South African financial markets in an attempt to see whether the theoretical view concerning the market movements is in line with the actual market movements. It has been concluded that in most cases the theoretical view is in line with reality except those period of market shocks. A number of observations were made from the graphs. Firstly we observed that there was a strong correlation between the SA T-bill index and the All share index. A second observation was that all the markets reacted to the September 11 attacks on the US and the 2007 to 2009 global crisis. Over the period 1997 to the end of 1999, South Africa financial markets were affected by a series of external shocks which were the major source of volatility in the markets. it was also observed that market relationships during crisis differ from the relationship during good period.

CHAPTER 4

DATA AND METHODOLOGY

4.1 INTRODUCTION

In this chapter the methodology to be used is explained. The framework provides the platform that will allow for the realisation of the objectives stated in Chapter One. The study will examine the volatility transmission among four South African financial markets which include the stock, bond, money and the foreign exchange market. The chapter also discusses the proxies and data used in this study. Following other empirical studies (see for example Mishra, 2004; Fang *et al*. 2006; Adjasi *et al*., 2008; Hakim and McAleer, 2008; Chiang and Li, 2009, Chinzara and Aziakpono, 2008), the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) to analyse volatility and to estimate conditional volatility series. These GARCH type of models will be estimated under three distributional assumption, the Gaussian, Student-t and Generalised Error Distribution (GED). To examine volatility transmission across the four domestic financial markets, the estimated conditional volatility series will then be analysed using the Vector autoregressive (VAR) together with block exogeneity, impulse response and variance decomposition. Volatility series for the international stock, bond and money will also be estimated using an appropriate GARCH model and the will be added into the VAR model to control for the effects of international financial markets volatility on domestic financial markets. Finally to analyse whether volatility transmission significantly differs between the bull and the bear periods of markets, volatility series are divided according to whether they relate to periods of increasing returns (bull) or decreasing returns (bear). Using a simple dummy variable OLS technique, we will then examine whether there is any significant differences in volatility transmission among the markets between these two periods.

The chapter is organised as follows: Section 4.2 discusses the univariate GARCH models. Section 4.3 describes the VAR model together with block exogeneity, impulse response and variance decomposition and how the control variables will be added into the model. Section 4.4 discusses the methodology that is used to distinguish between volatility transmission in bull and bear periods. Section 4.5 discusses proxies and data. Section 4.6 concludes the chapter.

4.2 ARCH FAMILY OF MODELS

There has been considerable volatility and uncertainty in the past few years in mature and emerging financial markets worldwide. Several models are available to model market volatility. The autoregressive conditional heteroscedastic (ARCH) family of models was specifically developed to model financial market volatility. The autoregressive conditional heteroscedastic (ARCH, see Engle, 1982) models have been widely employed since their introduction. The ARCH family models make use of only historical return data and involve volatility as an integrated aspect of the return behavior (Meng and Rafikova, 2006). One of the most appealing properties of ARCH models is their ability to accommodate volatility clustering, excess volatility and leverage effects. Most studies employ the multivariate VAR to analyze volatility interaction between financial markets. The ARCH model consists of two characteristics which include autoregression and Heteroskedasticity. Autoregression means that the model uses previous estimates of volatility to calculate subsequent (future) values. Hence volatility values are closely related. Heteroskedasticity occurs when the variance of the error terms differ across observations. Heteroskedasticity arises most often with cross-sectional data. The ARCH model is distinctive in that it specifies the variance of the error term (i.e. σ_t^2) in a regression equation as conditionally dependent on the lagged squared errors (u_{t-1}^2) (Brooks, 2008: 386). The simple ARCH model can be represented by the equation below:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 \tag{4.1}$$

The above model is known as an ARCH (1), given that the conditional variance depends on only one lagged squared error. Equation 4.1 is an incomplete model since it doesn’t include the conditional mean (Brooks, 2008: 388). The conditional mean is of essence because it describes how the dependent variable varies over time.

The full model which includes both the conditional variance and the conditional mean would be given by the model below:

$$y_t = b_1 + b_2 x_{2t} + b_3 x_{2t} + b_4 x_{4t} + u_t \qquad u_t \sim N(0, \sigma_t^2) \tag{4.2}$$
$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 \tag{4.3}$$

The model above can be extended to the general case where the error variance depends on q lags of the squared errors, which would be known as the ARCH (q) model:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-2}^2 + \cdots + \alpha_q u_{t-q}^2 \qquad (4.4)$$

Where, y_t is the conditional mean, u_t is the error term and, b_1, b_2 and b_3 are parameters to be estimated. In the variance equation, α_0, α_1 and α_2 are parameters to be estimated and σ_t^2 is the conditional variance, while q is the number of lags to be included and u_t are innovations. For an ARCH (q) model, all coefficients would be required to be non-negative that is the parameters must satisfy $\alpha_i \geq 0$ where i = 0, 1, 2. . . q.

However the ARCH model comes with its challenges which include difficulties in deciding the value for q (number of lags of the squared residual in the model), the required value of *q* might be very large and that non-negativity constraint might be violated. A natural extension of an ARCH (q) model which overcomes some of these problems is a GARCH model (Brooks, 2008: 392).

The Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model was developed independently by Bollerslev (1986) and Taylor (1986). This model is also a weighted average of past squared residuals but it has declining weights which never go completely to zero. The main advantage of GARCH over ARCH is that, ARCH(q) modeling requires relatively high values of q (lags of squared errors) for good fitting, while GARCH(1,1) is usually enough for fitting financial data (Engle, 2001). Generalised ARCH (GARCH) models are less likely to breech non-negativity constraints and are more parsimonious and avoid overfitting (Brooks, 2008: 393).

The GARCH model takes the same mean equation as Equation (4.2) but modifies the ARCH conditional variance equation as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta \sigma_{t-1}^2 \qquad (4.5)$$

Above is a GARCH (1, 1) model where σ_t^2 is the conditional variance, α_0 is a constant, α_1 is the coefficient of lagged squared residuals, u_{t-1}^2 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 $\alpha_1 + \beta < 1$ is necessary for stationarity of the GARCH model.

The GARCH (1, 1) model can be extended to a GARCH (*p*,*q*) formulation, where the current conditional variance is parameterized to depend upon *q* lags of the squared error and *p* lags of the conditional variance

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-2}^2 + \cdots + \alpha_q u_{t-q}^2$$
$$+\beta_1 \sigma_{t-1}^2 + \beta_2 \sigma_{t-1}^2 + \cdots + \beta_p \sigma_{t-p}^2 \qquad (4.6)$$

$$\sigma_t^2 = \alpha_0 + \sum_{i-1}^{q} \alpha_i\, u_{t-i}^2 + \sum_{j-1}^{p} \beta_j\, \sigma_{t-j}^2 \qquad (4.7)$$

The principal restriction of this model is that the non-negativity conditions may still be violated. Furthermore, the model does not allow for any direct feedback between the conditional variance and the conditional mean and finally GARCH models cannot account for leverage effects (Brooks, 2008: 404).

To overcome some of the above problems associated with the GARCH model, a huge number of extensions and variants have been proposed. In this study, we employ the EGARCH, GJR (TARCH) and GARCH-M extensions.

The exponential GARCH (EGARCH) model was proposed by Nelson (1991) to capture leverage effects in the conditional variance. The EGARCH model provides a model specification that allows separate effects of good news along with a structure to examine persistence of the volatility (Baharumshah and Wooi, 2007).

In the EGARCH model the natural logarithm of the conditional variance is allowed to vary over time as a function of the lagged error terms rather than lagged squared errors.The variance equation is given by

$$\text{In}(\sigma_t^2) = \omega + \beta\text{In}(\sigma_{t-1}^2) + \gamma\left(\frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}}\right) + \alpha\left[\frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}}\right] \qquad (4.8)$$

$\alpha+\beta < 1$, $\gamma \neq 0$ 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. A leverage effect would exist if , $\gamma < 0$. 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) (Chinzara, 2008: 37).

Apart from accommodating possible leverage effects, the EGARCH model is superior in that there is no need to artificially impose non-negativity constraints on the model parameters since the log(σ_t^2) is modeled giving positive σ_t^2 for either negative or positive parameters.

Another model than accounts for the asymmetric effect of the "news" is the GJR or TARCH model due independently to Zakoïan (1994) and Glosten, Jaganathan and Runkle (1993). The TARCH model is based on the assumption that unexpected changes in the market returns have different effects on the conditional variance of the returns. Good news goes with an unforeseen increase and hence will contribute to the variance through the coefficient β and bad news goes with a decrease and hence will contribute to the variance with the coefficient $\alpha+\gamma$ (Magnus and Fosu, 2006). The conditional variance is now given by

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta\sigma_{t-1}^2 + \gamma u_{t-1}^2 l_{t-1} \qquad (4.9)$$

Where $l_{t-1} = 1$ if $u_{t-1} < 0$

= 0 otherwise

In the TARCH model, "good news", $u_{t-1} > 0$ and "bad news", $u_{t-1} < 0$ have different effects on the conditional variance. When $\gamma \neq 0$, it means that the news impact is asymmetric and that there is a presence of leverage effects. The difference between the TARCH and the EGARCH models is that in the former the leverage effect is quadratic while in the latter, the leverage effect is exponential (Mapa, 2004).

Another model that can be used in modeling volatility is the GARCH-in-mean model (GARCH-M) Proposed by Engle, Lilien and Robins (1987). An example of a GARCH-M model is given by the specification

$$y_t = \mu + \delta\sigma_{t-1} + u_t \, , u_t \sim \mathrm{N}(0, \sigma_t^2) \quad (4.10)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta\sigma_{t-1}^2 \quad (4.11)$$

If δ is positive and statistically significant, then increased risk, given by an increase in the conditional variance, leads to a rise in the mean return. Thus δ can be interpreted as a risk premium (Brooks, 2008). An important hypothesis that has prevailed in financial markets is that more risky markets have higher returns than less risky ones. The GARCH-M model provides a practical way of modeling risk and return in such a manner that this hypothesis could be empirically investigated.

In order to estimate the above models, it is necessary to make assumptions about the distribution of the error term. According to Kovačić (2008) and Leon (2008), three error distributional assumptions are explored for each of the three models: *the Normal (Gaussian) distribution, the Student–t distribution and the Generalised Error Distribution (GED)*. The log-likelihood function under the normal (Gaussian) distribution is specified as follows:

$$l_t = -\frac{1}{2}\log(2\pi) - \frac{1}{2}log\sigma_t^2 - \frac{1}{2}(r_t - \theta r_{t-1})^2/\sigma_t^2 \quad (4.12)$$

Where r_t and r_{t-1} denote current and lagged returns respectively, $0<\theta<1$, *t* is the number of the observations and other variables are as defined earlier.

Since financial data is mostly characterised by fat tails, The Student–*t* distribution and the Generalized error distribution (GED) are usually used to account for this phenomenon. Under the Student–*t* distribution, the log-likelihood function takes the following form:

$$l_t = -\frac{1}{2}\log\left(\frac{\pi(v-2)\,\Gamma(v/2)^2}{\Gamma((v+1)/2)^2}\right) - \frac{1}{2}log\sigma_t^2 - \frac{(v+1)}{2}\log\left(1 + \frac{(r_t-\theta r_{t-1})^2}{\sigma_t^2(v-2)}\right) \quad (4.13)$$

Given $\Gamma(\,)$ is the gamma function and v>2 is the shape parameter which controls for the tail behaviour. It should be noted that as $v \to \infty$ the Student–*t* distribution converges to the normal distribution.

Nelson (1991) proposed the log likelihood under the GED as follows:

$$l_t = -\frac{1}{2}\log\left(\frac{(1/v)^3}{\Gamma(3/v)(v/2)^2}\right) - -\frac{1}{2}log\sigma_t^2 - \left(\frac{\Gamma(3/v)(r_t-\theta r_{t-1})^2}{\sigma_t^2\Gamma(1/v)}\right)^{v/2} \quad (4.14)$$

Where $\Gamma(\,)$ is defined as in Equation (4.13), v is a positive parameter (i.e. $v > 0$) that describes thickness of the tails. The GED is a normal distribution if $v=2$ and fat-tailed if $r<2$.

4.2.1 ESTIMATION ISSUES

a. The mean equation

Specifying the mean equation is the starting point of modeling volatility using GARCH type models. The mean equation can be a standard structural model, an autoregressive (AR) model or a combination of the two. An appropriate mean equation should be ‘white noisy’ i.e. its error terms should be serially uncorrelated. This study employs the following mean equation:

$$y_t = \mu + \varepsilon_t \quad (4.15)$$

Where,y_t, are returns for each of the financial markets and μ is a constant. The next step is to test the estimated model for autocorrelation using the Durbin Watson (DW) test. If the Durbin Watson statistic is very close to 2 it shows that there is no autocorrelation. If the Durbin Watson stat is not close to 2 there is evidence of autocorrelation. If there is evidence of autocorrelation, lagged values of the dependent variable will be added to the right hand side of the equation until serial correlation is eliminated. The appropriate mean equation will also be tested for ARCH effect.

b. Testing for Arch effects

Before proceeding to estimating volatility models it is appropriate to first compute the Engle (1982) test for ARCH effects to make sure that this class of models is appropriate for the data. There are two tests that may be employed to test for heteroscedasticity which include the ARCH LM and the white heteroscedasticity tests. The ARCH LM test is a Lagrange multiplier (LM) test for autoregressive conditional heteroscedasticity (ARCH) in residuals of an estimated equation (Engle, 1982). The presence of ARCH effects in the data does not invalidate standard inference, but ignoring it may result in a loss of efficiency (Eviews 5, 2004). This study will use the ARCH LM test since it is the most widely used method in previous literature.

The Langrage Multiplier (LM) test for heteroscedasticity is calculated by regressing the squared residuals on a constant and p lags, where p is the number of lags (Brooks, 2008: 390). The null hypothesis is of no autocorrelation in the data and two test statistics are reported, the F statistic and the Observations R-squared (follows an $x2$ distribution). If the test statistic is significant then there is evidence of ARCH effects in the data.

After analyzing the volatility of each of the four financial markets using the GARCH, EGARCH and GJR GARCH models, we then generate conditional variance series using the most appropriate of these three models. To come up with the most appropriate model we follow the approach used by Magnus and Fosu (2006). A combination of approaches such as stationarity of the GARCH models (i.e. $\alpha+\beta<1$), whether there is evidence of leverage/asymmetric effects in the data, whether the model passes diagnostic test ARCH-LM test and whether the model has minimum Akaike information criteria (AIC). The most appropriate model for each of the financial markets is then used to estimate conditional volatility/variance series of that specific market.

The estimated conditional variance series will serve as a proxy for volatility for each of the financial markets. The conditional variance series will then be analyzed using the VAR together with impulse response, variance decomposition and block exogeneity to examine the transmission of volatility among the four South African financial markets.

4.3 VECTOR AUTOREGRESSIVE (VAR)

The vector autoregressive (VAR) model is one of the most successful, flexible and simple to use models for the analysis of multivariate time series. The VAR model has proven to be especially useful for describing the dynamic behavior of economic and financial time series and for forecasting.

Vector autoregression (VAR) models were introduced by the macroeconometrician Sims (1980) to model the joint dynamics and causal relations among a set of macroeconomic variables. The vector autoregression (VAR) model is used for analyzing the interrelation of time series and the dynamic impacts of random disturbances (or innovations) on the system of variables (İnsel, 2010**)**. The VAR model clearly shows how returns and volatility are transmitted from one market to another in a recognized fashion. The VAR analysis is a useful tool to test for and examine spillovers and linkages between financial markets. VARs have often been advocated as an alternative to large-scale simultaneous equations structural models. VAR can be used for the purpose of stylizing empirical regularities among time series data (Bala and Premeratne, 2004).

Our study will express the VAR model as follows:

$$Y_t = C + \sum_{s=1}^{m} A_s X_{t-s} + \varepsilon_t \qquad (4.16)$$

Where Y_t is a 4 x 1 column vector of South African financial market returns for the four financial markets under consideration, C is the deterministic component comprised of a constant, As are respectively, 4 x 1 and 4 x 4 matrices of coefficients, m is the lag length and ε_t is the 4 x1 innovation vector. By construction ε_t, is uncorrelated with all the past Xs.

One of the appealing features about the VAR model is that there is no need to specify which variables are endogenous or exogenous since all are considered to be endogenous. VARs allow the value of a variable to depend on more than just its own lags or combinations of white noise terms, so VARs are more flexible than univariate AR models and therefore offer a very rich structure, implying that they may be able to capture more features of the data (Brooks, 2008).

In construction of a general VAR model, we determine the set of variables to include in the model and the appropriate lag length. In determining the variables, the included variables in a VAR model are selected according to the relevant economic theory. The selected variables must have economic influences on each other. In determining the lag length, the appropriate lag length must be determined by allowing a different lag length for each equation at each time and choosing the model with the lowest AIC and SIC values. The same sample period must be considered for different lag lengths. If the lag length is too small, the model will be misspecified; if it is too large, the degrees of freedom will be lost (İnsel, 2010).

The VAR estimates do not allow us to determine much about the transmission of shocks across the financial system or the period of time that it takes these shocks to work through the financial system. To counter for the above problems the VAR model is extended with block exogeneity, impulse responses and variance decompositions functions. These are discussed in detail below.

4.3.1 Block Exogeneity/ VAR Granger Causality

One of the major uses of VAR models is forecasting. 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. If a variable, or group of variables, Y_1 is found to be helpful for predicting another variable, or group of variables, Y_2 then Y_1 is said to Granger-cause Y_2; otherwise it is said to fail to Granger-cause Y_2. . The block exogeneity test follows an F-distribution (Brooks, 2002:339) and is analogous to testing for Granger causality. Clearly, the notion of Granger causality does not imply true causality. It only implies forecasting ability. In this study block exogeneity test is used to identify whether there is volatility transmission between the four financial markets.

4.3.2 Impulse Response Analysis

An impulse response function traces the response of the endogenous variables to one standard deviation shock to one of the disturbance terms in the system. An impulse-response function illustrates the response over time of each variable in the VAR to a one-time shock in any given variable while keeping all others constant. A shock to a variable is transmitted to all of the endogenous variables through the dynamic structure of the VAR. Therefore, an impulse response function shows the interaction between/among the endogenous variables sequence

(İnsel, 2010). In this study the impulse response will be used to show the response of SA financial markets to a one standard error unit shock in any of the markets. And this is done by capturing the sign, magnitude and persistence of responses of one financial market to shocks in another market.

4.3.3 Variance Decomposition Analysis

Variance decomposition analysis gives information about the dynamic behavior of the model and the relative importance of each random disturbances or innovation in the VAR. Variance decomposition shows the proportion of the movements in the endogenous variable sequence as a result of its own shocks against shocks to other variables. In this study, we use variance decomposition to measure the proportion of the movements in any of the financial markets that are explained by other markets. For example, this will look at how much of variations in SA's bond market volatility can be explained by innovations of the SA's foreign exchange market.

4.3.4 Controlling For Volatility Spillovers from International Financial Markets

To control for volatility transmission from international financial markets, the VAR model together with its various extensions as above re-estimated but this time volatility in the Intentional stock, money and bond market are also added.

4.4 VOLITALITY TRANSMISSION BETWEEN BULL AND BEAR PERIODS

This section tests whether volatility transmission between the financial markets differs in bull and bear phases of the markets. To analyse this hypothesis, a simple dummy variable ordinary least squares (OLS) equations were estimated taking into account whether the phases are of increasing or decreasing returns. Volatilities in international financial markets were also controlled for. Autoregressive terms were added in each of the models to address autoregressive problems. Volstock, volmoney, etc shows the interaction between the volatilities when the market trends are not taken into account (bull/bear). Bear*volstock, bear*volmoney shows the interaction when bear/bull distinction is taken into account.

4.5 PROXIES AND DATA

As proxies for the stock, bond, foreign exchange and money markets, we used the FTSE/JSE all share, All bond index, MSCI ZAR to 1 USD and the SA T-bill 91 days (tender rates) respectively. The FTSE global bond index, MSCI world stock index and the London interbank lending rate (LIBOR) are used as our proxies for the International markets for the bond, stock and money market respectively.

Data used comprise daily closing prices for each contract, obtained from Thompson DataStream, for the period July 1995 to April 2010 totaling 3869. Our starting period is justified by the pro-market policies after 1994 political democritisation. 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 that is reaction can even be within hours, minutes or seconds. Thus, lower frequency data distorts such reactions. To maintain a uniform measurement interval across markets, we exclude days when any of the four markets are closed meaning that weekends were not included in this study and also a holiday in the associated money markets results in that day being excluded from the creation of the series. We compute the daily continuously compounded returns (r_t) for each market as the percentage log of relative prices as follows:

$$r_t = 100\% \times \text{In}\left(\frac{p_t}{p_{t-1}}\right) \qquad (4.16)$$

Where p_{t-1} and p_t represent previous and current prices respectively.

4.6 CONCLUSION

This chapter systematically lay out the methodology that will be used to examine the volatility transmission between the South African financial markets. The chapter started by discussing the analytical framework for examining volatility transmission among financial markets. In this case we discussed univariate GARCH and its asymmetric extensions highlighting the strength and weaknesses of each model. We also discussed how these models are estimated and how they are utilised in examining the nature of volatility in financial markets. With regards to the modeling of volatility transmission across markets, the VAR and its extensions were discussed. Also discussed is how we will control for volatility influences from international financial markets. The methodology used to distinguish volatility transmission between bull and bear periods of the markets was then discussed. We also discussed the proxies and data used in this study. The next chapter presents and analyses the empirical findings of the study.

CHAPTER 5

ANALYSIS OF EMPIRICAL RESULTS

5.1 INTRODUCTION

The objectives set out in Chapter 1 were to: (i) examine the volatility transmission among the South African four financial markets, (ii) examine the long run trends in volatility in each of the markets so as to determine whether volatility transmission is increasing or decreasing, (iii) identify the dominant source of volatility within the domestic financial markets and (iv) identify whether a risk-return relationship exist in each of the financial markets. Thus far, the existing empirical literature has been reviewed and the analytical framework established. In order to address the objectives mentioned in chapter one, the present chapter deals with the application of this analytical framework.

The chapter is organised as follows: Section 5.1 discusses descriptive statistics and stationarity tests; Section 5.2 discusses the mean equation for the volatility models; Section 5.3 discusses the selection of the most appropriate GARCH model; Section 5.4 examines Volatility and volatility linkages across South African financial markets; Section 5.5 encompasses the control variables to see whether the international financial markets volatility affects the volatility in the local markets; Section 5.6 examines the transmission differences between bull and bear markets and Section 5.7 concludes the chapter.

5.2 DESCRIPTIVE STATISTICS AND STATIONARITY TEST

Table 5.1 lays out the descriptive statistics for the data used in the study. The statistics reported in the table below include the sample means, median, maximum, minimum, standard deviation, skewness, kurtosis, Jarque-Bera statistics with their p-values for the return series, Ljung-Box, ADF and KPSS.

Looking at the returns it is observed that stock market returns are larger (0.046) than those of any other financial markets. The returns for stock market ranges between the minimum of -7.897 to the maximum of 6.834. On the other hand the money market shows negative returns (-0.018) meaning that there was a downward market trend during the study period (bear market). Exchange rate has the second highest average returns and bond market the third with unconditional average returns of 0.007% and 0.005% respectively.

Considering the standard deviation it is observed that the stock market standard deviation of 1.331 is higher than for any other market indicating the existence of more risk in the stock market. The foreign exchange market has the second highest standard deviation, followed by the money market and the bond market with standard deviation of 1.108, 0.738 and 0.445 respectively.

Returns of the bond, stock and money markets are negatively skewed while returns for the foreign exchange market are positively skewed. Positive skewness indicates a distribution with an asymmetric tail extending towards more positive values. Negative skewness indicates a distribution with an asymmetric tail extending towards more negative values (Brown, 1997). All the financial markets under consideration have distributions with positive excess kurtosis and show evidence of fat tails. Kurtosis characterizes the relative peakedness or flatness of a distribution compared to the normal distribution. Positive kurtosis indicates a relatively peaked distribution. Negative kurtosis indicates a relatively flat distribution (Brown, 1997).

The Jarque-Bera (JB)[3] normality test is used to assess if the conditional distribution of the observed series is indeed normally distributed (Fiorentini, Sentana and Calzolari, 2003). As shown from the table below the Jarque-Bera statistic is highly significant at 1% level, which implies a rejection of the assumption of normality. As a result the series is not normally distributed.

LB (10) and LB^2 (10) are Ljung-Box statistics for 10 lags, calculated for returns and squared returns respectively .The Ljung-Box statistics *LB* (10) and LB^2 (10)[4] for the returns and squared returns series are both highly significant. Therefore, there is autocorrelation in the level of returns and squared returns. Considering the LB^2 (10) test results, this implies that there is evidence of volatility clustering and heteroscedasticity, thus the use of GARCH-type models for the conditional variance is justified as they capture the time-varying nature of conditional volatility (Kovačić, 2007:18)

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[3] Jarque-Bera test statistic tests hypotheses H_0: returns normally distributed, H_1: returns not normally distributed.
[4] LB^2 (10) statistic tests hypotheses H_0: volatility clustering, H_1: no volatility clustering.

Table 5.1: Descriptive statistics

	Mean	Median	Maximum	Minimum	Std.Dev	Skewness	Kurtosis	Jarq-Bera	LB(10)	$LB^2(10)$	ADF	KPSS
STOCK	0.046	0.017	6.834	-7.897	1.331	-0.179	6.547	1426.415[a]	41.043[a]	640.400[a]	-50.258[a]	0.101
BOND	0.005	0.000	5.078	-7.855	0.445	-1.619	49.985	2489.799[a]	167.61[a]	624.980[a]	-23.905[a]	0.173
EXR	0.007	0.000	9.808	-8.523	1.108	0.348	8.945	4021.417[a]	22.193[b]	620.700[a]	-48.879[a]	0.139
MONEY	-0.018	0.000	9.056	-9.025	0.738	-3.39	62.141	397768.2[a]	155.130[a]	887.530[a]	-18.197[a]	0.178

***Source**: Authors own estimates*
Note: $^{a,\,b,\,c}$ implies the coefficient is significant at 1%, 5% and 10% respectively.

Having looked at other descriptive statistics we now move on to see whether the series is stationary. According to Challis and Kitney, (1991) stationarity, is defined as a quality of a process in which the statistical parameters (mean and standard deviation) of the process do not change with time.

To access the time series behaviour of each of the time series two formal unit root tests were employed. In this case the Augmented Dickey Fuller (ADF) test and the one proposed by Kwaitokowski et al., (1992) (KPSS) test were employed to test for stationarity. The tests were performed using the 'no trend' deterministic trend assumption since the graphical plots showed no trend. The lag length selection for the ADF test was determined by the Schwarz information criterion (SIC) and the maximum lag length was set at 27. The KPSS was estimated using the Bartlett Kernel estimation method. The results of both tests are reported in Table 5.1.

The ADF tests the null hypothesis that the series has unit root, as a result the rejection of the null hypothesis would mean that the series does not have a unit root (i.e. is stationary). On the other hand, the KPSS has a null hypothesis that the series is stationary and rejecting the null hypothesis would mean that the series is non-stationary (i.e. has a unit root). Since all the series are significant at 1% level using the ADF test, we reject the null hypothesis and for KPSS we fail to reject the null hypothesis since it is insignificant at 10% level. Results from both the ADF and the KPSS show that, given the significance level of 1%, all the returns series are stationary at level.[5]

[5] The KPSS was used as a confirmatory test since the ADF test may be biased towards rejection of the null hypothesis in cases where the error terms follow an MA or ARMA process (see Davidson & MacKinnon, 2004:622).

5.3 THE MEAN-EQUATION FOR THE VOLATILITY MODELS

The starting point for all our estimations for each of the return series is the estimation of the mean equation. The estimated mean equation was then tested for autocorrelation using Durbin Watson (DW) test. There is evidence of autocorrelation in all the other markets except for the stock market variable. To resolve the autocorrelation we added an autoregressive lag to the mean equation. The appropriate mean equations were then tested for ARCH effect. The table 5.3 reports the DW statistics from the mean equations and ARCH LM F-statistics.

Table 5.2: Autocorrelation test for the mean equation

	DW STATISTIC	ARCH LM
BOND	1.9682	42.36715[a]
MONEY	2.0335	4.757010[c]
EXR	1.9972	5.674089[c]
STOCK	2.0006	9.224691[a]

Source: Authors own estimates

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

As evident from table 5.3 the DW statistic for all the four markets is closer to 2 meaning that there is no significant evidence of autocorrelation for the mean equations of each of the financial markets. It is also observed that the bond and the stock market show significant evidence of ARCH effect at 1% level and the money and foreign exchange market show significant evidence of ARCH effect at 10% implying that the mean equation did not adequately capture volatility in all the markets. The mean equations were therefore used for estimating the GARCH models.

5.4 DETERMINING THE MOST APPROPRIATE GARCH MODEL

Based on the appropriate mean equations for each of the markets, univariate GARCH, EGARCH and TARCH models were estimated and the results are reported in Table 5.4. The three GARCH models were tested under three distributions assumptions which include Normal, Student- t and the Generalised error distribution (GED) in order to come up with the best distribution which captures most volatility within the markets.

In selecting the appropriate model the following criteria were used, i.e. testing the presence of arch effect, the Condition for stationarity of the GARCH model ($\alpha+\beta$), the

Leverage/asymmetric coefficient (γ) and the information criteria, Schwarz information criterion (SIC) and Akaike information criterion (AIC). The coefficient δ is the *Arch–in mean* coefficient and it measures the relationship between volatility and returns.

The table 5.4 below presents the results of estimated models of market returns for the 4 South African financial markets under the 3 distributions which include normal distribution, student t distribution and the Generalised error distribution (GED):

																		LM		
47	0.070	-0.112[a]	0.147[a]	0.973	1.120	-0.080[a]	0.025[a]	0.053	3.148	3.128	0.078	0.035[a]	0.032[a]	0.889[a]	0.921	0.106[a]	0.040[b]	0.033	3.150	3.130
34	0.071	-0.094[a]	0.122[a]	0.974[a]	1.096	-0.085[a]	0.029[a]	0.818	3.139	3.117	0.085	0.034[a]	0.022[b]	0.898[a]	0.920	0.105[a]	0.047[b]	0.711	3.142	3.120
35	0.060	-0.105[a]	0.138[a]	0.974[a]	1.111	-0.081[a]	0.026[b]	0.022	3.141	3.119	0.075	0.034[a]	0.028[a]	0.893[a]	0.921	0.105[a]	0.044[c]	1.482	3.143	3.121
98	0.145[b]	-0.166[a]	0.167[a]	0.980[a]	1.148	-0.042[a]	0.012[a]	4.470[b]	0.822	0.803	0.128[c]	0.002[a]	0.054[a]	0.907[a]	0.962	0.047[a]	0.001[c]	2.635	0.814	0.794
36	0.156[b]	-0.175[a]	0.166[a]	0.976[a]	1.141	-0.031[a]	0.012	3.688[c]	0.757	0.735	0.121	0.003[a]	0.060[a]	0.901[a]	0.960	0.036[b]	0.001	2.084	0.757	0.735
36	0.139[b]	-0.173[a]	0.168[a]	0.977[a]	1.146	-0.034[a]	0.011	3.759[c]	0.759	0.737	0.116[c]	0.003[a]	0.058[a]	0.903[a]	0.961	0.039[b]	0.001	2.249	0.757	0.735
16	N/A	-0.429[a]	-0.932[a]	0.342[a]	- 0.589	0.905[a]	0.111[a]	0.161	1.892	1.876	N/A	0.475[a]	-0.014[a]	0.557[a]	0.542	0.001	0.046[a]	0.020	2.423	2.408
50	N/A	-1.284[a]	-0.267	0.484[a]	0.217	0.132	-0.169[a]	7.563[a]	-3.806	-3.823	N/A	0.399[a]	-0.010[a]	0.521[a]	0.510	0.000	0.010	0.036	1.964	1.946
587	N/A	-2.429[a]	-0.176[a]	0.313[a]	0.137	0.204[a]	-0.078[a]	2.019	-3.603	-3.620	N/A	0.202[a]	0.000	0.378	0.378	-0.004	-0.036	0.142	8.158	8.154
04	-0.101	-0.115[a]	0.148[a]	0.981[a]	1.129	0.035[a]	0.008	2.180	2.822	2.802	-0.082	0.012[a]	0.084[a]	0.920[a]	1.004	-0.031[a]	0.012[c]	1.089	3.929	3.924
79	-0.130[b]	-0.105[a]	0.135[a]	0.985[a]	1.120	0.031[a]	0.009	4.163[b]	2.799	2.777	-0.102	0.008[a]	0.076[a]	0.932[a]	0.987	-0.026[c]	-0.030	2.123	2.799	2.778
80	-0.114[c]	-0.110[a]	0.140[a]	0.983[a]	1.123	0.032[a]	0.010	3.164[c]	2.800	2.778	-0.095	0.010[a]	0.079[a]	0.925[a]	1.004	-0.028[b]	0.014[c]	1.710	2.801	2.779

ly.

In all the three models, the coefficient $\boldsymbol{\omega}$ represents the intercept and the coefficients α and β are the residual squared and variance squared coefficients respectively. In this case the intercept coefficient, ω is significant at 1% level for all the 3 models. The coefficient of the squared residual term, α is significant for all the markets except for the foreign exchange market under GARCH (GED) and the money market under EGARCH (student-t distribution). On average the coefficient of the lagged variance squared, β is significant at 1% for all models and the summation of the residual squared (α) and variance squared (β) coefficients is very high i.e. close to 1 for all the markets except for the money market. This implies that volatility is persistent.

The asymmetry coefficient, γ is only peculiar to the EGARCH and the TARCH models. This coefficient should be negative and significant for EGARCH and positive and significant for TARCH models if there is evidence of asymmetry. From table 5.4 it is evident that the for EGARCH the coefficient, γ is negative and significant at 1% for the stock and bond market and for TARCH the coefficient, γ is also positive and significant at 1% meaning that bad news leads to more volatility than positive news of the same magnitude for the stock and bond market unlike for the money and foreign exchange market. This implies that volatility is asymmetric and there is evidence of leverage effects in the stock and bond market unlike in the money and foreign exchange market.

Considering GARCH and EGARCH models the *arch–in mean* coefficient (δ) for the bond market is statistically significant under all distributions and that of foreign exchange market is only significant under student t distribution. This means that for the bond market and the foreign exchange under student t there is significant risk premium in returns unlike in other markets where there is no significant risk premium in returns. Considering the TARCH model it is observed that the arch-in mean coefficient is only significant for the bond market under normal and GED distribution meaning that only the bond market shows the significant risk premium in returns as compared to the other financial markets. As a result other financial markets are in contrast with the behavioural finance suggestion that more risky stock markets are more rewarding than less risky ones.

For the stationarity of the GARCH models, α and β should be less than 1. Considering the EGARCH model it is observed that $\alpha+\beta > 1$ for all the financial markets except for the money market. In addition to, the F-LM statistic for the EGARCH model is significant for the bond market, money market (student-t distribution) and foreign exchange market (student-t distribution and GED) meaning that this model has not adequately capture volatility for the stated markets. As a result we drop the EGARCH model making way for the GARCH and TARCH models.

Now comparing the GARCH and TARCH model it is observed that the GARCH model is stationary ($\alpha+\beta < 1$) for all the financial markets while the TARCH is stationary ($\alpha+\beta < 1$) for all markets except for the foreign exchange market which is only stationary under student-t distribution. For GARCH the F-LM statistic is significant for bond market (normal distribution) and foreign exchange market (student-t and GED) implying that in these 2 respective markets the model does not adequately capture volatility under these distributional assumptions. As a result we drop the GARCH model making way for the TARCH model which adequately captures volatility in all the markets.

Now that we have chosen the TARCH model as our most appropriate model we need to choose the most appropriate distribution under which volatility series will be generated for each market. For the stock market and the money market, student-t distribution was found to be more appropriate and for the foreign exchange market, normal distribution was found to be more appropriate since the summation of residual squared and variance squared coefficients ($\alpha+\beta$) was lowest at these distributions. For the bond market, student-t distribution was found to be the most appropriate distribution since the summation of ($\alpha+\beta$) was less than 1 and also the information criteria was lowest at this distribution.

Conditional variance/volatility series for each market was then estimated using the most appropriate model for each of the market as selected above.

5.5 MODELLING THE VOLATILITY TRANSMISSION ACROSS SA MARKETS

To examine volatility transmission across South African financial markets, a VAR model was estimated using the estimated conditional variance series. The appropriate lag order for the VAR model was initially determined using the AIC and SIC information criteria. These information criteria suggested a minimum lag order of 2 and a maximum of 20. However, diagnostic checking was done to ensure that the final lag selected give robust results. We started with a VAR lag length of 2 and the LM statistics was found to be insignificant meaning that we fail to reject the null hypothesis (No serial correlation) and conclude that there was no autocorrelation and as a result we estimated the VAR model using 2 lags. The results for the serial correlation diagnostic test and the serial lags of the VAR model are reported in Table 5.4 and table 5.5 respectively.

Table 5.4: Lag length selection criteria

Lag length	LM-Stat	Probability
1	23.35255	0.1046
2	22.41380	0.1303

Source: *Author's estimates*

Table 5.5: VAR results for volatility transmission across markets

	VOLSTOCK	VOLBOND	VOLEXR	VOLMONEY
VOLSTOCK(-1)	0.903		0.062	
	[45.603]		[5.178]	
VOLSTOCK(-2)	0.072			0.006
	[3.621]			[2.712]
VOLBOND(-1)		0.899		
		[44.238]		
VOLBOND(-2)		0.065	0.057	
		[3.217]	[1.432]	
VOLEXR(-1)		0.075	1.118	
		[7.126]	[54.170]	
VOLEXR(-2)				
VOLMONEY(-1)				0.514
				[26.657]
VOLMONEY(-2)				

Source: *Author's estimates*

Note: t-values in parenthesis reported are only the statistical significant results.

VAR analysis is a useful tool to test for examining volatility transmission and linkages between markets. Vector autoregression (VAR) allows the value of a variable to depend on more than just its own lags or combination of white noise terms (Brooks, 2008). This allows analysing the dynamic interaction between the four financial markets while at the same time assessing the importance of own past volatility on explaining current volatility.

From the table 5.5 it is evident that there is no statistically significant volatility transmission to the stock market from the other 3 financial markets. This result is not in line with theory as discussed in chapter 2. Particularly, the 'portfolio balance approaches', states that there is volatility transmission between the stock and foreign exchange market[6] (Frankel, 1993). Our result is partly in line with those of Mishra (2004) who investigated the linkages between the stock market and the foreign exchange market in India and found no significant relationship between the exchange rate return and stock return. On the other hand, studies by Aggarwal (1981), Soenen and Hennigar (1988) and Solnik (1987) found that there is significant volatility transmission between the stock market, the exchange rate and other markets. The reason why our result is in line with Mishra (2004) might be the fact that we used the same methodology (VAR) model.

Considering the bond market, it is observed that there is positive statistically significant volatility transmission with influence seemingly strong from the foreign exchange to the bond market. This result makes theoretical sense since it is in line with the theoretical view as suggested by the "Fisher effect" or inflation expectations channel[7]. Hurditt (2004) studied volatility transmission across Jamaican financial markets using the multivariate GARCH models and concluded that there is volatility transmission between the bond and foreign exchange market backing up our finding. This result seems to conform to the graphical illustration in Chapter 3 (see Figure 3.5) where there seem to be strong comovement between the bond and foreign exchange series.

On the other hand, the table 5.5 shows the presence of volatility transmission from the stock market to the foreign exchange market. This is an interesting result showing us that there is unidirectional causality from stock to the foreign exchange market not the other way round. This observation makes theoretical sense since it is backed up by the 'goods market

[6] See section 2.4.1 on the Interaction between stock and foreign exchange market.
[7] See section 2.4.5 on the Interaction between foreign exchange market and bond market.

approaches'[8]' (Dornbusch and Fischer, 1980), which suggest that there is transmission from the foreign exchange market to the stock market. The study done by Huzaimi and Liew (2004) found evidence of bi-directional causality between exchange rates and stock prices in Malaysia thus backing up our study. A study done by Hatemi-J and Irandoust (2002) supports our study in that they found unidirectional Granger causality from stock prices to effective exchange rates.

Lastly, focusing on the money market it is observed that there is statistically significant positive volatility transmission from the stock market to the money market. The above result makes theoretical sense since it is backed up in theory by (e.g. Alatiqi and Fazel, 2008), which stated that the relationship between the money market and the stock market is derived through the interest rate. This is also empirically consistent with a study by Fleming, Kirby and Ostdiek (1997) who found a strong volatility transmission between these markets.

Overall, from table 1.5 it can be concluded that there is limited volatility transmission among the four SA financial markets. What seems evident however is that own past volatility is the dominant source of current volatility for all the financial markets. As a compliment to the vector regression (VAR) model, using the same lag order of two, block exogeneity, impulse response and variance decomposition functions were also estimated. The results for the block exogeneity, impulse response and variance decomposition are reported in Table 5.6, Figure A2 (see appendix) and Table 5.7 respectively.

5.5.1 Block exogeneity test

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. The block exogeneity test follows an F-distribution (Brooks, 2002:339) and is analogous to testing for Granger causality. The results for block exogeneity are reported in Table 5.6 below.

[8] See section 2.4.1 on the Interaction between stock and foreign exchange market.

Table 5.6: Block exogeneity for volatility transmission

	Dependent variables			
Excluded variables	VOLSTOCK	VOLBOND	VOLEXR	VOLMONEY
VOLSTOCK		0.816 [0.67]	54.089[0.00]	7.939[0.02]
VOLBOND	0.721 [0.70]		21.300[0.00]	0.301[0.86]
VOLEXR	0.168 [0.92]	51.727[0.00]		1.201[0.55]
VOLMONEY	1.109 [0.57]	0.145 [0.93]	0.415 [0.82]	

Source: *Author's estimates.*

Note: Parentheses [ ] are used to denote the probability values.

As shown in the Table, all the three financial markets insignificantly influence stock market volatility. This is also in support of the VAR result which showed that there is no volatility transmission to the stock market from the other three financial markets. Considering bond market, only exchange rate volatility is significant at 1% meaning that the other markets have no statistically significant effect to the volatility of the bond market. Except for the money market, all the other financial markets influence volatility in the foreign exchange market. Considering the money market volatility as the dependant variable, only the volatility of the stock market is significant at 1% level implying that only the stock market volatility influence the money market volatility. The block exogeneity result can also be interpreted in terms of the exogeneity of each of the variables included in the VAR system. In this regard the stock market is the most exogenous since it tends to significantly influence other markets but not significantly influenced by any of them. The block exogeneity results are in line with the VAR results.

5.5.2 Impulse response

The impulse response function was estimated using the Generalised approach and the results are reported in Figure 2 (see Appendix). We will start by looking at the response of the stock market volatility to one standard deviation shock in its own innovation. In this case the response is instant, positive and very significant. The response gradually decreases but does not die off. It is evidenced that the response of the stock market volatility to a one standard deviation shock in the innovation of the other three financial markets is quite instant, positive and persistent. However the response is very insignificant.

The response of the bond market volatility to one standard deviation shock in its own innovation is instant, positive and very significant though it gradually decreases as time goes on. It is also persistent since it doesn't die off to zero. The response of the bond market volatility to one standard deviation shock in the foreign exchange market is quite significant, positive and it tends to decrease after two days. The speed of the response is also very high. The response of the bond market volatility to the one standard deviation shock in the innovations of the stock market is positive, insignificant and gradually decreases through time. Moreover, the response of the bond to the shock in the money market is very insignificant and is it dies off after approximately 3 days.

Moving on the response of the volatility in the foreign exchange to the one standard deviation shock in the innovations of the stock and bond market, it is seen that the response is quite significant, positive, instant, steadily increase but becomes constant and persistent with time. The response of the foreign exchange volatility to the shock in the money market is positive and instant, but extremely insignificant and it dies off to zero after 26 days. Now focusing on the response of the foreign exchange volatility to one standard deviation shock in its own innovation, Figure 2 shows that the response is very high, very significant, positive and persistent although it gradually decreases with time.

Finally, the responses of the money market volatility to one standard deviation shock in the error term of the volatilities of the stock, bond and foreign exchange market is negative, instant but very insignificant and dies off by the 4^{th} day. On the other hand, the response of the money market volatility to one standard deviation shock in its own innovations is positive, very significant and rapidly decreases from the first day and dies off by the seventh day.

From the results above it is clear that the response of each of the four financial market volatility to its own past volatility is generally higher than the response to other error variance shocks from the other financial markets.

5.5.3 Variance decomposition

Variance decompositions show the proportion of the movements in the explained financial markets that are due to its 'own' innovations, against those from other markets. In this case we only reported the variance decomposition results for 2, 5, 10, 15, 20, 25 and 30 steps ahead in table 5.7. The main focus is to examine which of the market volatilities mostly influence SA financial markets volatilities.

Table 5.7: Variance decomposition for volatility transmission

Variance Decomposition of VOL_STOCK				
Period	VOL_STOCK	VOL_BOND	VOL_EXR	VOL_MONEY
2	99.972	0.019	0.002	0.007
5	99.885	0.035	0.011	0.068
10	99.800	0.061	0.023	0.116
15	99.740	0.091	0.035	0.134
20	99.686	0.124	0.047	0.142
25	99.635	0.160	0.057	0.148
30	99.586	0.197	0.067	0.151
Variance Decomposition of VOL_BOND				
Period	VOL_STOCK	VOL_BOND	VOL_EXR	VOL_MONEY
2	0.819	98.216	0.962	0.003
5	1.135	97.253	1.609	0.003
10	1.286	97.145	1.566	0.003
15	1.348	97.239	1.411	0.003
20	1.374	97.345	1.279	0.003
25	1.379	97.437	1.181	0.002
30	1.373	97.512	1.113	0.002
Variance Decomposition of VOL_EXR				
Period	VOL_STOCK	VOL_BOND	VOL_EXR	VOL_MONEY
2	8.374	9.041	82.578	0.007
5	12.006	10.504	77.472	0.018
10	16.580	13.459	69.931	0.030
15	20.572	16.088	63.302	0.038
20	23.982	18.233	57.740	0.045
25	26.821	19.905	53.223	0.050
30	29.146	21.171	49.628	0.054
Variance Decomposition of VOL_MONEY				
Period	VOL_STOCK	VOL_BOND	VOL_EXR	VOL_MONEY
2	0.192	0.154	0.052	99.602
5	0.203	0.191	0.056	99.551
10	0.250	0.201	0.056	99.493
15	0.301	0.205	0.056	99.438
20	0.343	0.208	0.057	99.393
25	0.377	0.210	0.057	99.356
30	0.406	0.211	0.057	99.326

Source: *Author's estimates*

As evident from Table 5.7, own past volatility of the stock market tends to explain most of the current variation of itself approximately 99.972% during the second day, 99.740% by the 15th day and 99.586 by the end of the month. This confirms that the volatility of the stock market is exogenous, a finding also shown by VAR and block exogeneity. Analysing the volatility for the bond market, it is also observed that approximately 98.216%, 97.239% and 97.512% by the second, 15th and 30th day respectively of the variation in the bond market is explained by itself compared to that explained by the other financial markets. In this case the bond market is said to be exogenous, however the volatility in stock and foreign exchange equally contribute just above 2%, with the money market not explaining any significant variation in the bond market.

On the other hand, volatility of the foreign exchange market tends to be explained by other markets. Own past volatility explain (approximately 82.578%) at day 2 but it decreases gradually with time to about 49.628% by month end. The bond and the stock market volatility tend to be important in explaining the variation in the volatility of exchange rate with the stock market contributing just marginally above what is contributed by the bond market. For the money market, volatility of the money market explains most of the variation of itself (99.602% by day 2). Table 5.7 shows that at day 2, 99.062% of the variation of the money market volatility is explained by itself compared to less than 0.05% explained by the other financial markets. Thus the money market proved to be an exogenous market.

Our results from block exogeneity, impulse responses and variance decomposition tend to be very consistent. Basing on results for the block exogeneity, impulse responses and variance decomposition reported above there is limited evidence that there is volatility transmission across South African financial markets.

5.6 ROBUSTNESS CHECKS: controlling for foreign financial markets volatility

Our findings suggested possible interactions among some of the financial markets in SA. In order to test for robustness of this result, we controlled for international financial markets volatility.

In the case of our study we now include the international financial markets as our control variables to see whether the international financial markets volatility affects the volatility in the local markets. We have used the FTSE global bond index, MSCI world stock index and the London interbank lending rate (LIBOR) as our control variables for the bond, stock and money market respectively. The fact that volatility in international markets affects South

Africa's financial markets is backed up by a number of authors including a paper by (Chinzara, 2008). The reason for this could be that investors may also factor international risk or because of market globalisation.

5.6.1 Variance decomposition with control variables

This section reports the variance decomposition results with the inclusion of international financial markets. As shown in Table A1 (see appendix), the volatility of the stock market tends to explain most of the variation of itself approximately 99.062% followed by the volatility of the world stock markets which explains only 0.693% of the variation of the stock market in day 2. At period 15 and 30, it is observed that the stock market explains 82.014% and 71.178% of itself respectively. With the inclusion of the world markets, the stock market no longer explains most variation of itself since the volatility of world stock markets explains 13.168% and 21.317% of the variations in the stock market respectively. In other words the local stock market responds to the variations in the world stock markets. Considering the bond market, approximately 98% of the variation is explained by itself. The bond market proved to be an exogenous market since not even the international markets can explain its variation. About 0.75% of its variation is explained by the world stock market at period 30. This shows that international markets have very little effect (<1%) on the variation of the SA bond market.

Volatility of exchange rate tends to explain most of the variation of itself roughly 93% in a period of 30 days. The international markets explain approximately 3% of the variation. This shows that the international markets have a very small effect on the variation of the SA foreign exchange market. Coming to the money market, Table A1 shows that the money market explains less that 50% of the variation of itself from day 10 up to day 30. Most of its variation is explained by the bond market volatility and the volatility in the world stock market. As a result it is evidenced that the world stock market volatility has a greater effect on the volatility of the SA money market and also that the money market is a very endogenous market with the inclusion of the international markets.

In a nutshell, this section highlighted that the international markets volatility is importance in the local market volatility. That is the shocks in the international markets will eventually affect the movement in the local markets with time except for the bond market in the case of

South Africa which proved to be very exogenous despite the inclusion of international markets volatilities.

5.6.2 Block exogeneity with control variables

This section reports the block exogeneity results with the inclusion of international financial markets. The Table 5.8 reports the results of the block exogeneity for volatility transmission with the control variables.

Table 5.8: Block exogeneity for volatility transmission

	Dependant variables						
Excluded Variables	VOL_STOCK	VOL_BOND	VOL_EXR	VOL_MONEY	VOL_WLDSTOCK	VOL_GLBLBOND	VOL_LIBOR
VOL_STOCK		10.777[1.00]	91.703 [0.00]	25.216[0.71]	108.631[0.00]	52.937[0.01]	56.338 [0.00]
VOL_BOND	141.112[0.00]		716.839[0.00]	11.391[1.00]	84.223 [0.00]	27.593[0.59]	40.740 [0.09]
VOL_EXR	115.438[0.00]	53.495[0.01]		26.894[0.63]	336.654[0.00]	46.440[0.03]	57.952 [0.00]
VOL_MONEY	14.613 [0.99]	5.707 [1.00]	18.003 [0.96]		36.405 [0.20]	34.158[0.27]	41.525 [0.08]
VOL_WORLDSTOCK	177.843[0.00]	20.515[0.90]	338.142[0.00]	36.969[0.18]		78.740[0.00]	169.402[0.00]
VOL_GLOBALBOND	106.071[0.00]	79.436[0.00]	164.581[0.00]	43.984[0.05]	156.394 [0.00]		44.651 [0.04]
VOL_LIBOR	57.166 [0.00]	21.019[0.89]	46.494 [0.03]	49.214[0.01]	73.730 [0.00]	48.377[0.02]	

Source: *Author's estimates.*

Note: Parentheses [ ] are used to denote the probability values.

As shown in Table 5.8, all the other markets except for the money market significantly influence stock market volatility at 1%. This shows that there is volatility transmission to the stock market from all other markets except for the money market. With the inclusion of the international markets the bond and the foreign exchange market tend to influence the stock market volatility unlike when considering the local financial markets (see table 5.6). Considering bond market, foreign exchange and the global bond market volatilities are significant at 1% meaning that the other markets have no statistically significant effect to the volatility of the bond market. Except for the money market, all the other financial markets influence volatility in the foreign exchange market since they are all significant at 1% level. Looking at the money market volatility, it is observed that only the global bond market and the London interbank lending rate (LIBOR) is statistically significant meaning that except for the global bond and the LIBOR market there is no volatility transmission from the other markets to the money market.

Coming on to the effects of the international markets to the SA financial markets, results on Table 5.8 shows that volatility transmission from the world stock market is significant at 1% for all the markets except for the bond and the money market. This implies that there is no volatility transmission from the world stock market to the SA bond and money market. On the other hand, the volatility transmission from the world bond is significant at 1% for all the financial market meaning that there is volatility transmission from the world bond market to all the SA markets financial markets. Considering the London interbank lending rate (LIBOR), it is evidenced that there is volatility transmission from the LIBOR market to all the other SA markets except for the bond market.

In summary, there is volatility transmission from the international financial markets to SA financial markets to a larger extent since the volatility transmission is statistically significant at 1% for most of the financial markets.

5.6.3 Impulse response with control variables[9]

This section looks at the response of the local markets to the volatility of the international markets. Figure A3 (see Appendix) shows how the SA financial markets respond to the international financial markets volatilities.

We will start by looking at the response of the stock market volatility to one standard deviation shock in the innovation of the world stock market. In this case the response is significant and positive. The response gradually increases from day one up to day 15. After the 15th day it gradually decreases but does not die off. For the world bond market, it is seen that the response of the stock market is positive and significant. It slowly increases from day 5 and is persistent up to the end of the month. Getting on to the LIBOR market, the response of the stock market volatility to the shock in the money market volatility is very insignificant and it dies off after approximately 5 days.

Moving on to the response of the volatility in the bond market to the to the one standard deviation shock in the innovation of the world stock and the LIBOR market, it is noticed that the response is positive and extremely insignificant. Considering the effects of the world

[9] This section will not discuss the responses of the SA financial markets to the volatilities of the local markets since it has been already been done in Section 5.4.2.

bond market on the local bond market, the response of the bond market is very insignificant and is negative from the 15th to the 20th day. For the response of the volatility in exchange rate to the one standard deviation shock in the innovation of the world stock, figure A3 shows that the response is quite instant, positive and steadily increases from the first day up to day 15. It tends to decrease after day 15 but does not die off to zero. The response of the volatility of exchange rate to the shock in the global bond volatility is instant and negative from day one to the fifth day. It gradually increases from day 20 up to the end of the month. For the response of the volatility of exchange rate to the shock in the volatility of LIBOR, it is seen that the response is negative up to the fifth day and from there it becomes positive from day ten and it gradually increases up to the end of the month.

Lastly considering the response of the volatility of the money market to a one standard deviation in the other three world markets, it is evidenced that the response of the money market is instant, very insignificant for all the markets and it dies off before the fifth day of the month. As a result, it is of greater evidence from the discussion above that there is limited volatility transmission from the international markets to the SA financial markets.

5.7 TRANSMISSION DIFFERENCES BETWEEN BULL AND BEAR MARKETS

In this section we test whether volatility transmission between the financial markets differs in bull and bear phases of the markets. Several authors have found that stock market volatility is higher during bear markets than in bull markets (Maheu and McCurdy, 2000; Gomez Biscarri and Perez de Gracia, 2004; Jones *et al*., 2004; Gonzalez *et al*., 2005; Nishina *et al*., 2006; Tu, 2006; Cunado *et al*., 2007; etc.) according to Jones *et al.* (2004) there are two possible explanations for the higher volatility during bear markets which include: (a) the increased uncertainty and risk observed in the bear market may generate a decline in equity value (b) In the context of increased uncertainty investors react to bad news more quickly, adding then more volatility to the market.

Table A2 (in appendix) shows whether the volatilities in the SA financial markets present a different behaviour in bull and bear phases. Starting with the stock market, in the case of domestic financial markets when exchange rate is depreciating (bear phase) volatility transmission from the foreign exchange market to the stock market tend to increase since it is positive and significant at 1%. On the other hand when the when the bond and the money market are in their bear phases the volatility of the stock market tend to be insignificant. This shows that volatility transmission from the bond market and the money market to the stock market does not significantly differ between the bear and bull market phases. In the case of international markets, difference in the volatility transmission to the SA stock market between the bull and bear periods in the international financial markets is only significant in the case of international stock markets. In other words if the world bond and the world money markets are in their bear phases the SA stock market volatility is not significantly affected differently from when share markets are in bull periods.

As shown in table A2 (appendix) looking at the bond market, focusing on the domestic markets, when the exchange rate is in its bear phase the volatility of the bond market tend to be significant meaning that the volatility transmission from the foreign exchange market to the bond market increases when the exchange rate is in its bear phase. The volatility transmission from the stock market, bond market and the money market to the bond market does not significantly differ between the bear and bull market phases. For the international markets, it is observed that for all the international markets, the volatility of the SA bond market is insignificant implying that the volatility transmission from all the international markets to the SA bond market does not differ whether the markets are in their bull or bear phases.

Now coming on to the foreign exchange market, the bear market coefficients for the bond and stock markets are significant at 1% and for the money market at 10%. This means that volatility transmission from the other 3 markets to the foreign exchange market tend to increase when these markets are doing bad (bear period). For the international markets, only the world stock market is significant implying that negative returns from the world stock market increases the volatility transmission from the international stock to the foreign exchange market. When the international bond and money market are doing good or bad, there is no difference in the volatility transmission to the foreign exchange market since they are not statistically significant.

For the money market, domestically volatility transmission from the other markets to the money market is not affected by whether the other markets are in their bull or bear periods since all the bear coefficients are statistically insignificant. Only the bear coefficient for the world money market is significant at 10% meaning that volatility transmission is from the world money market to the domestic money market is higher when there is depreciation in the world money market.

In conclusion it is evidenced above that both the world and local markets are important in accelerating the volatility transmission in SA financial markets depending on whether they are in their bull or bear phases. It is also of greater importance to note that local markets are of greater influence to the volatility transmission is SA financial markets as compared to the effects of the world markets.

5.8 CONCLUSION

This chapter presented and discussed the estimations and results with regard to different issues regarding the volatility transmission between SA financial markets. First section of this chapter discussed the descriptive statistics. The descriptive statistics showed non normality, excess kurtosis and volatility clustering which is in line with the properties of financial data. Having looked at the descriptive statistics we moved on to see whether the series was stationary. Results from both the ADF and the KPSS showed that all the returns series are stationary at level.

We then went on to estimate the mean equation for each of the returns series. The mean equation was then tested for autocorrelation using the Durbin Watson (DW) test. The mean equation was also tested for Arch effect to check whether volatility had been captured. Thereafter, the ARCH family of models was employed to estimate market volatility. To examine volatility transmission across South African financial markets, a VAR model was estimated for all the conditional variance series. The block exogeneity, impulse response and variance decomposition functions were also used to complement the VAR model and the results from the mean returns indicate volatility transmission between the financial markets. The relationships between the foreign exchange market and the bond market were found to be very strong as compared to the other markets.

In addition to the local markets, we also included the international markets as our control variables to see whether the volatility transmission between South African domestic financial markets is affected by the international markets behaviour. It was observed that shocks in the international markets have limited affect the movement in the local markets with time and that results were robust. The study also looked at the transmission differences between bull and bear markets. In this section we test whether the financial markets volatilities transmission are different in bull and bear phases for both local and international markets and was found that both the world and local markets are important in accelerating the volatility transmission in SA financial markets depending on whether they are in their bull or bear phases.

CHAPTER 6

SUMMARY OF FINDINGS, POLICY RECOMMENDATIONS AND AREAS FOR FUTHER RESEARCH

6.1 SUMMARY OF THE STUDY AND CONCLUSIONS

The study analysed the volatility transmission across South African markets and to show whether the volatilities in the SA financial markets present a different behaviour in bull and bear phases. This was done to see the relationship among the four financial markets, with a view to giving policy recommendation and investment advice to South African investors. The study also examine whether international markets affect the volatility in the SA financial markets.

The initial step in our study was to review the exiting relevant literature. Here we outlined the roles of the financial markets and the types of financial markets which include the money market, bond market, stock market and the foreign exchange market. Theoretical linkages between financial markets were also reviewed thus showing the interaction between the markets. After this the empirical literature was reviewed stating with the empirical literature for the stock and foreign exchange market, the bond and the stock market and lastly any other relevant literature. Empirical literature found significant volatility spillovers from the foreign exchange market to the stock market and also that bidirectional causality exists between stock market returns and bond market returns. Chapter three of the study discusses the relationship between the financial markets basing on the actual data recorded from Thompson Data stream to see whether it is in line with theory. It has been concluded that that in most cases the theoretical review is in track with the actual market movements.

In order to address our objectives, we used the GARCH, EGARCH and TARCH models assuming three different distributions, namely Gaussian, Student –*t* and the GED. The results showed that for all the markets, volatility is persistent and asymmetric. The three models (GARCH, EGARCH and TARCH) were compared and TARCH was found to be the most appropriate model. Based on the TARCH model, conditional variance series were generated and used as a proxy for volatility. The conditional variance series were then analysed using the VAR framework, block exogeneity, impulse response and variance decomposition. Using the VAR framework to analyse the volatility transmission across markets, the study concluded that there is limited volatility transmission among the four SA financial markets. What seems evident however is that own past volatility is the dominant source of current volatility for all the financial markets.

Results from block exogeneity showed that only the exchange rate volatility influences the volatility in the bond market. Except for the money market, all the other financial markets influence volatility in the foreign exchange market. The money market is said to be influenced only by the volatility of the stock market. It is also concluded that the stock market is the most exogenous since it tends to significantly influence other markets but not significantly influenced by any of them. Considering the variance decomposition, own past volatility of the financial markets tend to explain most of the current variation of itself than what is explained by the other markets.

In addition to, the study also looked at the response of the SA financial markets to the volatility of the international markets. The results concluded that there is volatility transmission from the international markets to the SA financial markets although it is limited. We also test whether volatility transmission between the financial markets doffers in bull and bear phases of the markets. The results evidenced that both the world and local markets are important in accelerating the volatility transmission in SA financial markets depending on whether they are in their bull or bear phases

Overall, the results for the block exogeneity, impulse responses and variance decomposition reported above shows limited evidence that there is volatility transmission across South African financial markets. Since the transmission is said to be limited, this implies that there is potential for gains from portfolio diversification in the financial markets.

6.2 POLICY AND INVESTMENT IMPLICATIONS

The findings of this study have important implications for investment and policy strategies. Since the volatility transmission between South African financial markets is limited, it implies that portfolio diversification may be worthwhile for SA portfolio managers. In this case investors are encouraged to diversify their financial instruments to hedge against risk. As a result, policy makers could capitalise on the fact that the SA financial markets offer greater potential for portfolio diversification to attract foreign investors.

On the other hand, the fact that volatility transmission across some markets is high for instance the volatility transmission between the stock and the foreign exchange market should be of greater concern to policy makers. Volatility will intern influence the financial stability of the country. Volatility between financial markets was observed to be high during the bear market periods. Considering the world markets, volatility transmission from the international markets to the local markets was said to be high when the world markets where in their bear periods. If such harmful volatility is transmitted into the SA financial markets this will threaten financial stability. As a result policy makers should regulate international financial market operations make sure that harmful volatility is limited from reaching SA financial markets.

Although it is often difficult to minimise the volatility transmission from one market to the other, it could be useful to ensure a stable macroeconomic and political environment as a way of minimizing the transmission. Policy makers need to be aware of the South African financial markets in response to external shocks.

6.3 AREAS FOR FURTHER RESEARCH

Since 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. further research in this area could employ the multivariate GARCH model and compare the results with ours and for comparison sake, different data frequencies could also be employed other than daily data.

APPENDIX

Table A1: Variance decomposition with control variables

Variance Decomposition of VOLSTOCK							
PERIOD	VOLSTOCK	VOLBOND	VOLEX_R	VOLMONEY	VOLWORLDSTOCK	VOLWORLDBOND	VOLWORLDMONEY
2	99.062	0.001	0.001	0.215	0.693	0.000	0.028
5	97.118	0.004	0.011	0.919	1.730	0.081	0.138
10	90.516	1.584	0.076	0.719	6.493	0.485	0.126
15	82.014	1.457	0.121	1.072	13.168	2.030	0.138
20	76.477	1.207	0.253	0.914	18.247	2.595	0.308
25	73.033	1.059	0.459	0.847	20.958	3.286	0.358
30	71.178	0.962	0.544	0.871	21.317	4.786	0.343
Variance Decomposition of VOLBOND							
PERIOD	VOLSTOCK	VOLBOND	VOLEX_R	VOLMONEY	VOLWORLDSTOCK	VOLWORLDBOND	VOLWORLDMONEY
2	0.216	99.152	0.000	0.451	0.034	0.059	0.088
5	0.136	99.393	0.002	0.272	0.053	0.091	0.053
10	0.079	99.342	0.004	0.156	0.276	0.102	0.042
15	0.066	99.019	0.018	0.268	0.409	0.129	0.093
20	0.061	98.622	0.015	0.314	0.620	0.203	0.164
25	0.092	97.982	0.015	0.353	0.702	0.378	0.479
30	0.123	97.450	0.015	0.379	0.744	0.639	0.650
Variance Decomposition of VOLEX_R							
PERIOD	VOLSTOCK	VOLBOND	VOLEX_R	VOLMONEY	VOLWORLDSTOCK	VOLWORLDBOND	VOLWORLDMONEY
2	0.297	0.165	99.266	0.065	0.206	0.001	0.001
5	0.324	0.194	98.439	0.133	0.518	0.148	0.244
10	0.358	0.199	97.362	0.248	0.888	0.642	0.302
15	0.448	0.218	95.657	0.586	1.191	0.732	1.169
20	0.472	0.239	95.078	0.800	1.290	0.864	1.256
25	0.501	0.242	93.964	1.010	1.360	0.988	1.934
30	0.703	0.270	93.454	1.062	1.371	1.112	2.027
Variance Decomposition of VOLMONEY							
PERIOD	VOLSTOCK	VOLBOND	VOLEX_R	VOLMONEY	VOLWORLDSTOCK	VOLWORLDBOND	VOLWORLDMONEY
2	4.457	9.917	0.132	84.604	0.647	0.217	0.026
5	3.964	20.002	0.072	74.373	0.909	0.493	0.186
10	4.947	39.724	0.031	48.091	6.694	0.430	0.083
15	7.610	37.503	0.033	40.690	13.553	0.360	0.252
20	9.318	35.433	0.034	36.386	17.856	0.357	0.614
25	10.310	33.251	0.032	33.950	20.663	0.827	0.967
30	11.423	31.211	0.057	32.495	21.891	1.698	1.226

Table A2: Transmission differences between bull and bear markets

	VOLSTOCK	VOLBOND	VOLEX_R	VOLMONEY
CONSTANT	0.13(0.29)	0.03(0.42)	0.04(0.59)	0.41(0.00)
VOLSTOCK		-0.0003(0.88)	0.01(0.02)	-0.001(0.11)
VOLBOND	0.12(0.00)		0.20(0.00)	0.001(0.75)
VOLEX_R	-0.06(0.00)	0.01(0.00)		-0.002(0.22)
VOLMONEY	-0.06(0.67)	-0.05(0.25)	-0.01(0.89)	
VOLWORLDSTOCK	0.11(0.00)	0.008(0.01)	0.04(0.00)	0.002(0.03)
VOLWORLDBOND	0.28(0.08)	0.019(0.71)	0.03(0.74)	0.014(0.46)
VOLWORLDMONEY	-0.001(0.00)	0.0001(0.6)	-0.002(0.00)	0.0001(0.00)
BEAR*VOLSTOCK		0.003(0.14)	0.01(0.00)	0.00(0.93)
BEAR*VOLBOND	-0.03(0.32)		-0.09(0.00)	0.00(0.98)
BEAR8VOLEXR	0.04(0.00)	0.02(0.00)		0.001(0.39)
BEAR*VOLMONEY	-0.02(0.52)	-0.01(0.51)	0.04(0.09)	
BEAR*VOLWORLDSTOCK	0.041(0.00)	-0.001(0.67)	-0.01(0.09)	0.001(0.22)
BEAR*VOLWORLBOND	0.11(0.17)	0.03(0.24)	0.019(0.71)	-0.01(0.54)
BEAR*VOLWORLDMONEY	0.001(0.68)	-0.00(0.36)	0.00(0.56)	0.001(0.09)
VOLSTOCK(-1)	0.87(0.01)			
BEAR*VOLSTOCK(-1)	0.0019(0.76)			
VOLBOND(-1)		0.94(0.00)		
BEAR*VOLBOND(-1)		-0.02(0.12)		
VOLEX_R(-1)			0.90(0.00)	
BEAR*VOLEX_R(-1)			0.01(0.03)	
VOLMONEY(-1)				0.50(0.00)
BEAR*VOLMONEY(-1)				0.01(0.06)
R2	0.95638	0.936663	0.969527	0.26578
DW	2.009957	1.975601	1.99075	1.967737
F	4215.32(0.00)	2843.56(0.00)	4116.56(0.00)	70.61(0.00)
AIC	0.893217	-1.378761	-0.069943	-3.423535
SIC	0.926082	-1.345896	-0.037079	-3.39068

Figure A1: Graphical plots of returns series

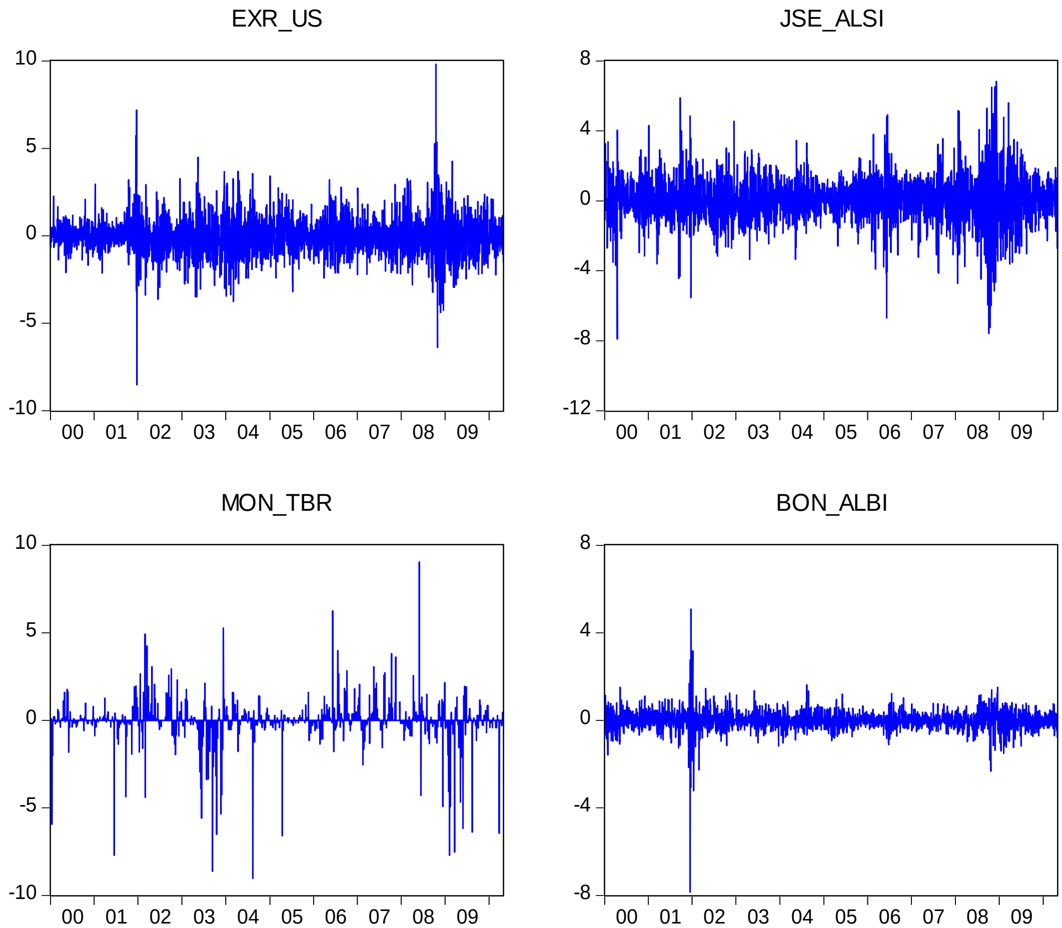


Figure A2: Impulse response functions for volatility linkages

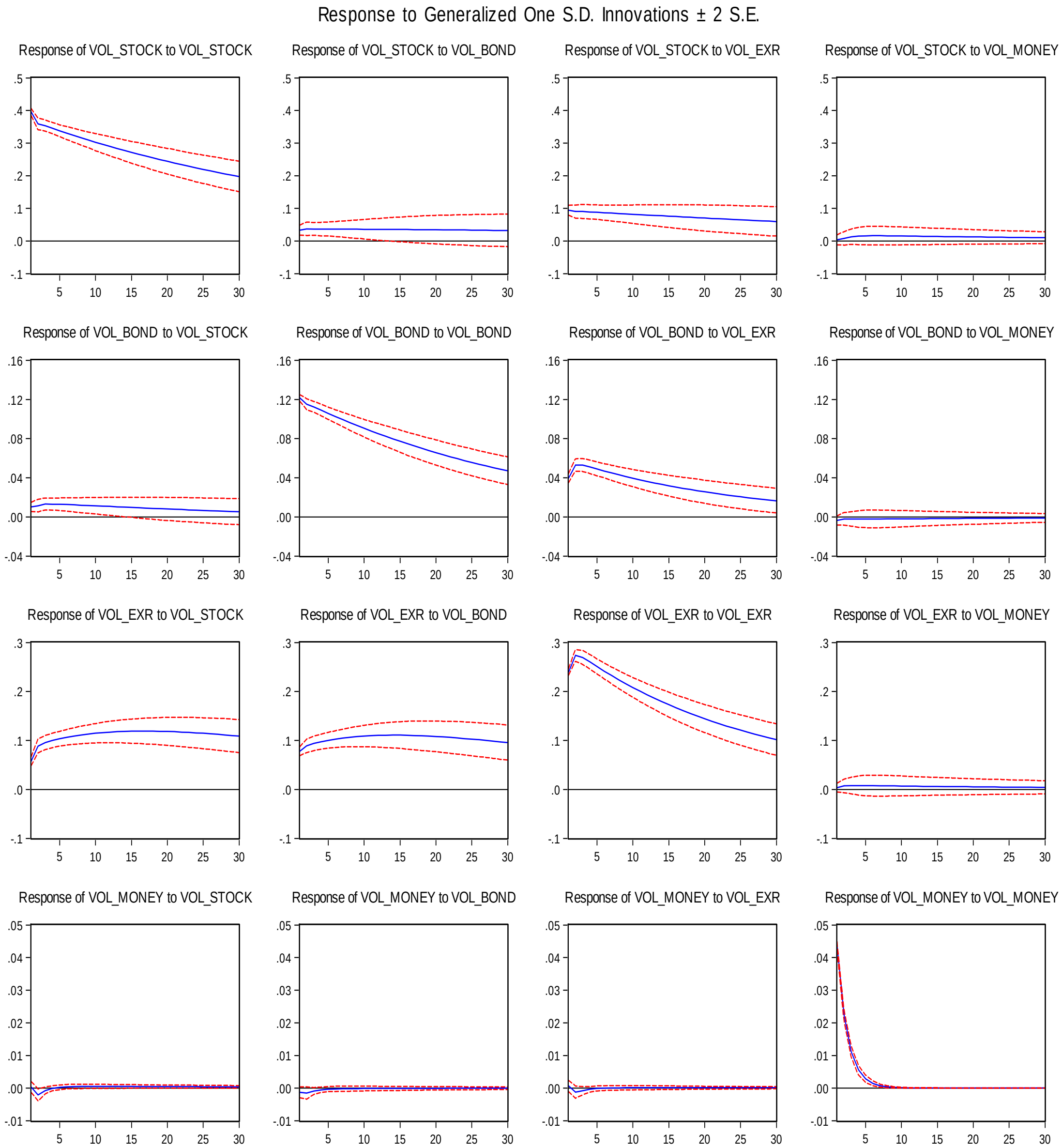
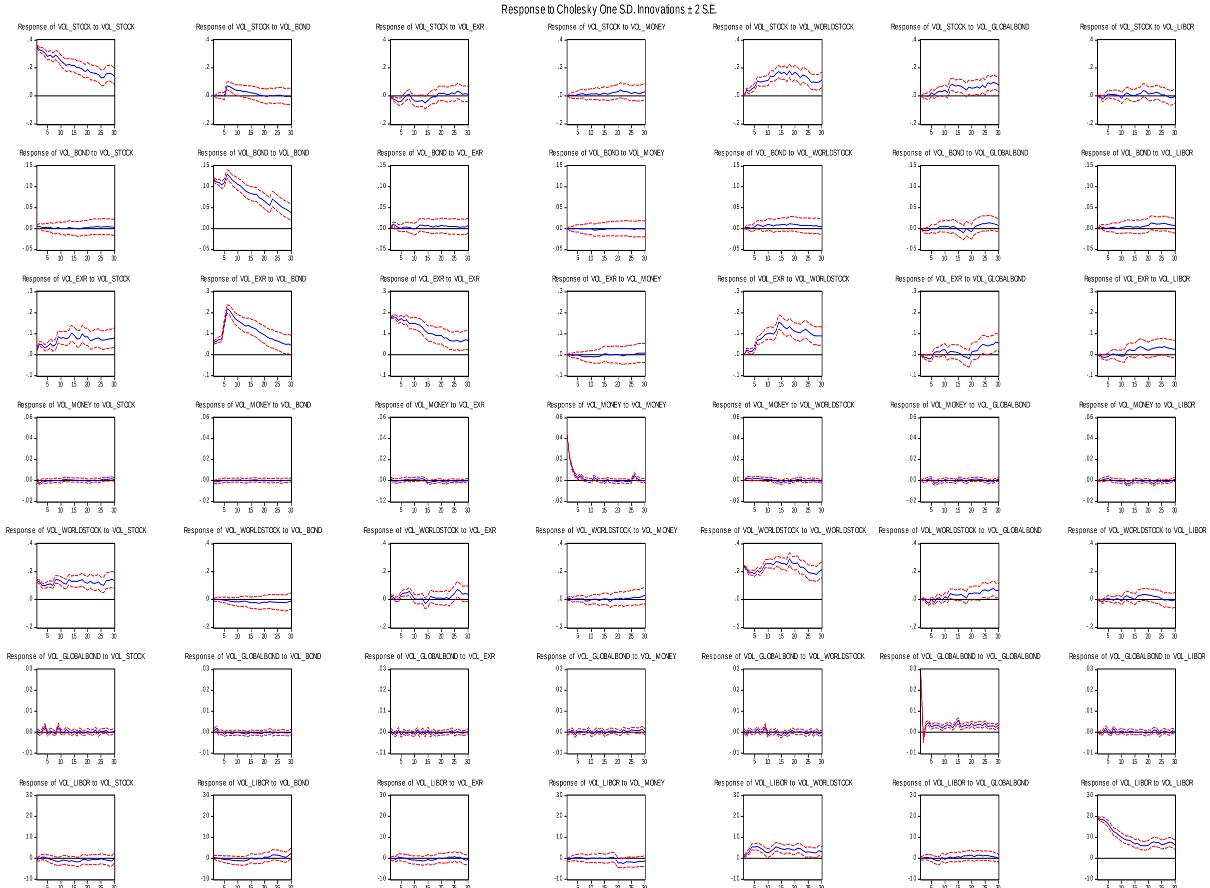


Figure A3: Impulse response functions with control variables



LIST OF REFERENCES

ADJASI., C, HARVEY., S and AGYAPONG, D., 2008. **Effect of exchange rate volatility on the ghana stock exchange.** African Journal of Accounting, Economics, Finance and Banking Research Vol. 3. No. 3. 2008.

AGGARWAL, R. 1981. **Exchange Rates and Stock Prices: A Study of U. S. Capital Market under Floating Exchange Rates**. Akron Business and Economic Review, vol. 12, 1981, pp. 7-12.

ALATIQI, S AND FAZEL, S., 2008. **Can money supply predict stock prices?** Journal for economic educators. 8, 2: 54- 58.

ALATIQI., S AND FAZEL S., 2008. **Can money supply predict stock prices**? Journal from economic educators, 8(2)

ANSARI, M., S., 2006. **Primary and secondary markets**. Articles heaven. [online]. Available:http://www.articles-heaven.com/articles/?Primary-and-Secondary Markets&articleid=347 [Accessed March 2010].

ANTELL, J., 2004. **Volatility Linkages in the Finnish Stock, Bond, and Money Markets.** Hanken School of Economics.

BAHARUMSHAH, A.Z and HOOY, C., 2007. **Exchange Rate Volatility and the Asian Financial Crisis: Evidence from South Korea and ASEAN-5.** Review of Pacific Basin Financial Markets and Policies (RPBFMP), 2007, vol. 10, issue 02, pages 237-264

BALA, L and PREMARATNE, G., 2004. **Stock market volatility: Examining North America, Europe and Asia**. [online]. Available: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=375380 [Accessed 12 June 2010].

BOLLERSLEV, T., 1990. **Generalized Autoregressive Conditional Heteroskedasticity**. *Journal of Econometrics.* 31, 307-327

BONFIGLIOLI, A. and FAVERO, A., C., 2005. **Explaining co-movement between stock markets: The Case of UK and Germany**. Journal of International Money and Finance. 24(8), 1299-1316.

BRADFIELD, J., 2007. **Introduction to the economics of financial markets**. Oxford university press.

BROOKS, C., 2002. **Introductory econometrics for finance**. Cambridge, New York. Cambridge University Press.

BROOKS, C., 2008. **Introductory econometrics for finance.** Cambridge, New York: Cambridge University Press. Pg 379-448.

BROWN, J.D., 1997. **Skewness and kurtosis.** JALT Testing & Evaluation SIG Newsletter, 1 (1) April 1997 (p. 20-23).

CAIRO., 2008. **The role of financial markets in achieving a sustainable economic development process**. The political economy of euro-med govemance.

CHALLIS, R. E. and KITNEY, R. I. (November 1991). "**Biomedical signal processing (in four parts). Part 1 Time-domain methods**." *Medical & Biological Engineering & Computing*, 28, 509-524

CHIANG. C.T. and LI, J., 2009. **The Dynamic Correlation between Stock and Bond Returns.** Department of Finance, Drexel University.

CHINZARA Z. AND AZIAKPONO M.J., (2008). **Dynamic returns linkages and volatility transmission between South African and the world major stock markets.** Paper presented at EMG conference, Cass Business School, City University, London, 14-16 May 2008.

CHINZARA, Z. (2008). **An empirical analysis of the long-run comovement, dynamic returns linkages and volatility transmission between the world major and the South African stock markets**. Masters thesis, Rhodes University.

COLLINS, D and BIEKPE, N., 2003. **Contagion and interdependence in African stock markets**. The South African Journal of Economics. Die Suid-Afrikaanse Tydskrif vir Ekonomie. Vol. 71:1 March / Maart 2003.

CUNADO, J., GIL-ALANA, L.A., PEREZ de GRACIA, F., 2007. **US stock market volatility before and after the burst of the IT bubble**. Mimeo.

DALY, K. J., 2003. **Southeast Asian stock markets linkages**: Evidence from pre and post-October 1997. ASEAN Economic Bulletin. 20, 73-85.

DORNBUSCH, R. and S. FISCHER., 1980, "**Exchange Rates and Current Account**," American Economic Review 70, 960-71

DORNBUSCH, R. and S. FISCHER.,1980. "**Exchange Rates and Current Account**," American Economic Review 70, 960-71..

EBRAHIM S. K. (2000), "**Volatility Transmission Between Foreign Exchange and Money Markets**," Financial Markets Department, Bank of Canada Working Paper No. 2000-16 http://www.bankofcanada.ca/en/res/wp/2000/wp00-16.html (accessed on 8th May 2010)

EHRMANN, M., FRATZSCHER, M. and RIGOBON, R., 2005**. stocks, bonds, money markets and exchange rates measuring international financial transmission.** European central bank. Working paper series no. 452

ENGLE, R. F., 1982**. Autoregressive conditional Heteroskedasticity with estimates of the variance of United Kingdom inflation**. *Econometrica.* Vol 50.

ENGLE, R.F. and KRONER, K.F., 1995. "**Multivariate Simultaneous Generalized ARCH**," Econometric Theory, Cambridge University Press, vol. 11(01), pages 122-150, February.

ENGLE, R.F, LILIEN, D.M and ROBINS, R.P., 1987. **Estimating time varying risk premia in the term structure: The ARCH-M model.** Econometrica. 55, 2:391-407

ENGLE, R.F., 2001. **GARCH 101: The use of ARCH/GARCH models in Applied Econometrics**. [online]. Available: http://www.marshallinside.usc.edu/simrohoroglu /teaching/543/spring2002/garch101.pdf [Accessed May 2010]

EVIEWS MANUAL., 2004. **Help system**. [Online]. Available: www.eviews.com [Accessed 17 June 2010].

FANG, V., Y.C. LIM and C.T. LIN., 2008. **Volatility Transmissions Between Stock And Bond Markets: Evidence From Japan And The U.S.** Adelaide Graduate School of Business and School of Commerce, University of Adelaide, Australia

FAURE, A. P., 2006c. **The Equity market**. Cape Town: Quoin Institute.

FAURE, P., 2005. **Getting to grips with the bond market**. Cape Town: Quoin Institute

FAURE, P., 2008. **Money market**. Cape Town: Quoin Institute

FIORENTINI, G., SENTANA, E. and CALZOLARI, G., 2003**. On the validity of the jarque-bera normality test in conditionally heteroskedastic dynamic regression models.** CEMFI Working Paper No. 0306

FISCHER, S., 2003. **The importance of financial markets in economic growth**. Citigroup International. 21 August 2003.

FLEISCHER, P., 2003. **Volatility and information linkages across markets and countries**. Australian journal of management, volume 28, No 3. December 2003.

FLEMING, J, KIRBY,C and OSTDIEK, B., 1997. **Information and volatility linkages in the stock, bond and money markets**. Journal of financial economics.

FORBES, J. K and RIGOBON,R., 2002. **No Contagion, Only Interdependence: Measuring Stock Market Comovements.** The Journal of Finance, Vol. 57, No. 5 (Oct., 2002), pp. 2223-2261

GAGNON, J.E. 2005,. **Currency Crashes and Bond Yields in Industrial Countries**. International Finance Discussion Papers vol 837.

GAGNON., 2005. **Currency Crashes and Bond Yields in Industrial Countries.** International Finance Discussion Papers. No 837: 2- 20.

Gomez Biscarri, J., Perez de Gracia, F., 2004. **Stock market cycles and stock market development in Spain.** Spanish Economic Review 6, 127-151.

GOODSPEED, I., 2008. **Introduction to financial markets**. Spot and forwards in SA Treasurer.

HAKIM, A., MCALEER, M., 2008**. Forecasting conditional correlations in stock, bond and foreign exchange markets.** School of Economics and Commerce, University of Western Australia.

HATEMI-J A. and IRANDOUST M. **(2002) "An Analysis of Exchange Rates and Stock Prices: Evidence for Sweden".** Published in Bulletin of Economic Research, Vol. 44(2).

HURDITT, P., 2004. **An Assessment of volatility transmission in the Jamaican financial system.** [online]. Available: http://www.boj.org.jm/uploads/pdf/papers_pamphlets/papers_pamphlets_an_assessment_of_volatility_transmission_in_the_jamaican_financial_system.pdf [accessed on February 2009].

HUSSAIN, H AND LIEW, V, K., 2004. **Casual relationships between exchange rates and stock prices in Malaysia and Thailand during the 1997 currency crisis turmoil.** Department of Economics, UiTMCS, Kota Samarahan, Sarawak.

HUZAIMI, H and LIEW, V.K., 2004. **Causal relationships between exchange rate and stock prices in Malaysia and Thailand during the 1997 currency crisis turmoil.** [online]. Available: http://129.3.20.41/eps/if/papers/0405/0405015.pdf [Accessed September 2010].

INSEL, A., 2010. **Econometrics time series analysis and econometric modelling**. Lecture 6 slides.

JONES, C.P., WALKER, M.D., WILSON, J.W., 2004. **Analyzing stock market volatility using extreme day measures**. Journal of Financial Research XXVII, 585-601.

JONES, C.P., WALKER, M.D., WILSON, J.W., 2004. **Analyzing stock market volatility using extreme day measures.** Journal of Financial Research XXVII, 585-601.

KAUL, I., 2006. **Balanced globalisation: the role of financial markets**. United Nations Development Programme.

KING, W., 2009. **A brief introduction of money market instruments**. [online]. Available: http://ezinearticles.com/?A-Brief-Introduction-of-Money-Market-Instruments&id=3440595 [Accessed March 2010].

KOVAČIĆ, Z.J. 2007. **Forecasting volatility on the Macedonian stock exchange**. *The Open Polytechnic of New Zealand*, Paper No. 5319, posted 07. November 2007.

KWAN, S, H. 1996. "**Firm-Specific Information and the Correlation between Individual Stocks and Bonds**." *Journal of Financial Economics* 40, pp. 63-80.

LAMBA, S. A. and OTCHERE, I., 2001. **An analysis of the linkages among African and world equity markets**. *The African Finance Journal*. 3(2), 1-25.

LASTRAPES, W AND MCMILLIN, D., 2004. **Monetary policy: how financial markets influence its effectiveness.** co-editor of the Journal of Macroeconomics.

LI, L., 2002. **Macroeconomic factors and the correlation of stock and bond returns**. Yale University Department of Economics Yale International Center for Finance.

LIM, E.S., GALLO, J.G. and SWANSON, P.E., 1998. **The Relationship between International Bond Markets and International Stock Markets.** International review of financial analysis / vol. 7(2).

LITTLE. K., 2009. **Understanding bond prices and interest rates**. [online]. Available: http://stocks.about.com/od/understandingstocks/a/Bondint111004.htm. [Accessed March 2010].

MAGNUS, F.J and FOSU, O.E., 2006. **Modelling and Forecasting Volatility of Returns on the Ghana Stock Exchange Using Garch Models.** American Journal of Applied Sciences 3 (10): 2042-2048, 2006

Maheu, J.M., McCurdy, T.H., 2000. **Identifying bull and bear markets in stock returns**. Journal of Business and Economic Statistics 18, 100-112.

MAPA, D.S., 2004. **The Generalized AutoRegressive Conditional Heteroskedasticity Parkinson Range (GARCH-PARK-R) Model for Forecasting Financial Volatility**. School of Statistics, University of the Philippines.

MENG, Y and RAFIKOVA, N., 2006. **Forecasting volatility: evidence from the Swedish stock market**. Stockholm school of economics.

MISHKIN, F. S., 2004. **The economics of money, banking and financial markets**. Boston Mass: Addison Wesley.

MISHRA, A.K. (2004), "**Stock Market** and **Foreign Exchange Market in India: Are they**. **Related**?", South Asia Economic Journal, Vol.5, No.2, Pp.209-232.

NATH, G, C AND SAMANTHA, G, P., 2003. **Relationship Between Exchange Rate and Stock Prices in India – An Empirical Analysis.** NSEIL, Bandra-Complex, Mumbai.

NELSON, D. B., 1991. **Conditional Heteroskedasticity in Asset Returns: A New Approach**. *Econometrica.* 59(2).

NISHINA, K., MAGHREBI, N., HOLMES, M.J., 2006. **Are volatility expectations characterized by regime shifts? Evidence from implied volatility indices**. Discussion Papers in Economics and Business 06-20.

NIEH, C. and LEE, C., 2001. **Dynamic relationship between stock prices and exchange rates for G-7 countries.** Department of Banking & Finance, Tamkang University, Tamsui, Taipei, 251, Taiwan

PAN, M., FOK, R., LUI. Y., 2007. **Dynamic linkages between exchange rates and stock prices: Evidence from East Asian markets**. Department of Finance and Information Management and Analysis, Shippensburg University, Shippensburg, USA

PIESSE, J. and HEARN, B., 2002. **Equity Market Integration versus Segmentation in Three Dominant Markets of the Southern African Customs Union**: Cointegration and Causality Tests. *Applied Economics*.

RIGOBON, R and SACK, B., 2003. **Spillovers across U.S financial markets.** [online]. Available: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=402121 [Accessed July 2010].

SHARMA, V. K., 2010. **Volatility in stock market**. [online]. Available: http://ezinearticles.com/?Volatility-In-Stock-Market&id=2783765. [Accessed 11 March 2010].

SHIKWAMBANA, J., 2007. **Financial instability in South Africa: trends and interactions within the financial markets**. Unpublished Masters' Thesis. Economics Department. Rhodes University.

SMITH, 2006~~.~~, **Explaining money market**. [online]. Available: http://www.talkinmince .com/Art/16730/57/Explaining-the-Money-Market.html. [Accessed 12 April 2010].

SOENEN, L. A. AND HENNIGAR, E. S. ,1988. **An Analysis of Exchange Rates and Stock Prices: the U.S. Experience between 1980 and 1986**. Akron Business and Economic Review, vol. 19, 1988, pp. 7–16.

SOLNIK, B., 1987. **Using Financial Prices to Test Exchange Rate Models**. The Journal of Finance, Vol. 42, No. 1 (Mar., 1987), pp. 141-149.

STIVERS, C AND SUN, L,. 2002. **Stock Market Uncertainty and the Relation between Stock and Bond Returns**. Working Paper vol 3.

STOCK MARKET INVESTORS., 2008. **Bond Prices and Bonds-Interest Rates Relationship.** [online]. Available: http://www.stock-market-investors.com/stocks-and-bonds investing/bond-prices-and-bonds-interest-rates-relationship.html. [Accessed April 2010].

TAHIR, R AND GHANI, A, A., 2002. **Relationship Between Exchange Rates and Stock Prices: Empirical Evidence from Bahrain's Financial Markets.** Unpublished MSc thesis. Grahamstown: Dept of Economics, Rhodes University.

THE WORLD BANK, 1998. **What effect will East Asia's crisis have on developing countries**? Economic policy. March 1998.

Tu, J., 2006. **Are bull and bear markets economically important?** Mimeo.

VAN EES, H AND GARRETSEN, H., 1993. **Financial markets and the complementarity of asymmetric information and fundamental uncertainty.** Journal of Post Keynesian Economics, Vol. 16, No. 1 (Autumn, 1993), pp. 37-48.

YANG, S. AND S. DOONG (2004), **Price and Volatility Spillovers between Stock Prices and Exchange Rates: Empirical Eviderice from the G-7 Countries**, *International Journal of Business and Economics* 3: 139-153. [ ]