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**FINANCIAL INSTABILITY IN SOUTH AFRICA: TRENDS AND
INTERACTIONS WITHIN THE FINANCIAL MARKETS**

A thesis submitted in partial fulfilment of the
requirement of the degree of

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JAMELA SHIKWAMBANA

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Supervisors: Professor Pierre Faure
Meshach Aziakpono

Abstract

This study seeks to investigate the trends and interactions of market volatility as a source of instability in the South African financial markets. Financial instability can be manifested in the form of banking and currency crisis, institutional failures and extreme asset price volatility. This study, however, focuses on a single aspect of financial instability - asset price volatility. Asset price volatility reflects changes in market expectations as investors react to such changes, and thus on its own is not necessarily a source of instability. However, volatility spillovers can propagate volatility shocks across the market, increasing the risk of widespread instability.

Using a combination of graphical and trend analysis as well as more formal estimation techniques, the study examined volatility in the stock, money and foreign exchange markets. To obtain estimates of market volatility, the study experimented with various volatility models that include the GARCH, TARARCH and EGARCH. An analysis of volatility interactions and the transmission of volatility shocks across the market is crucial to understanding financial instability. To examine volatility interaction and the transmission of volatility shocks, a VAR model was estimated. This framework allowed us to examine the propagation of shocks across the markets.

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. Significant linkages between the financial markets were found. The links also extended to the volatility relationship as evidenced by significant volatility spillovers across the markets. While volatility spillovers from the money market were found in the stock market and the foreign exchange market, no volatility spillovers from these markets were found in the money market. Thus the money market was identified as the major source of volatility spillovers and shocks in the financial markets. These results highlighted the role of monetary policy in the financial system, specifically the need to make monetary policy stable and predictable to ensure that interest rate shocks are not an additional source of instability.

Table of contents

<i>Abstract</i>	<i>ii</i>
<i>Table of contents</i>	<i>iii</i>
<i>List of tables</i>	<i>vi</i>
<i>List of graphs</i>	<i>vii</i>
<i>Acknowledgments</i>	<i>viii</i>

CHAPTER ONE: INTRODUCTION

1.0	Context of the study	1
1.1	The objectives of the study.....	4
1.2	The method of the study.....	5
1.3	Organisation of the study	6

CHAPTER TWO: CONCEPTUAL AND THEORETICAL FRAMEWORK

2.0	Introduction	7
2.1	Financial markets.....	8
2.2	Financial instability	12
2.3	Financial markets and instability: interactions and links	18
2.4	Stock prices and exchange rates	22
2.5	Stock prices and interest rates	24
2.6	Exchange rates and interest rates.....	28

2.7	Conclusion.....	32
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CHAPTER THREE: EMPIRICAL LITERATURE

3.0	Introduction	33
3.1	Stock prices and interest rates	34
3.2	Exchange rates and stock prices	43
3.3	Exchange rates and interest rates.....	52
3.4	Conclusion.....	54

CHAPTER FOUR: OVERVIEW OF TRENDS AND BEHAVIOUR OF THE SOUTH AFRICAN MARKETS

4.0	Introduction	56
4.1	The long term behaviour of the exchange rate	56
4.2	Long term behaviour of stock prices	60
4.3	Interest rate movements	65
4.4	Summary	68
4.5	Conclusion.....	69

CHAPTER FIVE: METHODOLOGY

5.0	Introduction	71
5.1	Empirical models.....	73
5.2	Data and estimation issues	81
5.3	Conclusion.....	87

CHAPTER SIX: EMPIRICAL RESULTS

6.0	Introduction.....	89
6.2	Results.....	92
6.3	Modelling volatility spillovers: Multivariate VAR of conditional variances.....	107
6.4	Conclusion.....	116

CHAPTER SEVEN: SUMMARY OF FINDINGS AND POLICY RECOMMENDATIONS

7.0	Summary of main findings.....	117
7.1	Policy proposals.....	121

<i>Appendices</i>	<i>124</i>
-------------------------	------------

<i>Bibliography</i>	<i>132</i>
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List of tables

<i>Table 4.1: Periods of exchange rate depreciation.....</i>	<i>59</i>
<i>Table 4.2: Periods of exchange rate appreciation</i>	<i>60</i>
<i>Table 4.3: Periods of sharp increases in the repo rate</i>	<i>66</i>
<i>Table 6.1: Summary statistics.....</i>	<i>91</i>
<i>Table 6.2: Unit root tests.....</i>	<i>93</i>
<i>Table 6.3: Results of estimating a multiple regression model of market returns.....</i>	<i>95</i>
<i>Table 6.4: Results of estimating univariate volatility models for stock prices.....</i>	<i>101</i>
<i>Table 6.5: Results of estimating univariate volatility models for treasury bill rates</i>	<i>103</i>
<i>Table 6.6: Results of estimating univariate volatility models for exchange rates.....</i>	<i>105</i>
<i>Table 6.7: Results of trend analysis.....</i>	<i>107</i>
<i>Table 6.8: Results of multivariate VAR of market volatilities.....</i>	<i>108</i>

List of graphs

<i>Figure 4.1: Long term performance of the rand against the dollar in the past 28 years.....</i>	<i>57</i>
<i>Figure 4.2: Long term movement of the all share index: 1973 to 2006.....</i>	<i>61</i>
<i>Figure 4.3: The all share index and resources index</i>	<i>64</i>
<i>Figure 4.4: The long run movement of the three month treasury bill rate</i>	<i>65</i>
<i>Figure 4.5: Long term movement of exchange rates and interest rates</i>	<i>69</i>
<i>Figure 6.1: All share index, treasury bill rate and exchange rate over the sample period.....</i>	<i>92</i>

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CHAPTER ONE

INTRODUCTION

1.0 CONTEXT OF THE STUDY

Financial stability is important, to ensure the effective operation of the financial system - both financial markets and institutions. Financial instability is manifested in the form of currency crisis, institutional failures, asset price volatility and sharp declines in asset prices. While asset price volatility is generally associated with financial instability, asset price volatility is not necessarily undesirable since it reflects the process of pricing and transferring of risks as the underlying circumstances change (IMF, 2003:62). However, sharp declines in asset prices have been linked to payment problems, institutional failures and widespread economic losses. In East Asia asset price declines were linked to corporate bankruptcies and problems within the banking sector. Banks were particularly vulnerable due to their exposure to non-performing loans of the private sector (Corsetia, Pesentib and Roubini, 1999).

In the absence of sharp declines in asset prices, volatility is still a source of concern. This is because volatility creates uncertainty in the market which leads to the misallocation of resources. The money market provides a channel for the implementation of monetary policy (Faure, 2003:236). In addition, through its links to asset prices and the rest of the economy, disturbances in this market can destabilise other financial markets. In particular, exchange rates and stock price movements are highly correlated with interest rate movements. Thus interest rate volatility is directly related to asset price volatility. On the other hand, interest rate volatility creates uncertainty about the future direction of economic policies, increasing the risk of speculation in the market. Thus, given its links to the economy and other asset prices, interest rate volatility can be a source of wide spread market instability.

On the other hand, asset price volatility can be an additional source of market instability. In the stock market, volatility discourages investments, impeding the efficient allocation of resources. According to the IMF (2003:68), the level of equity prices is directly related to economic activity. In addition, the stock market provides a barometer for the health of the economy, thus any instability in this market is directly related to real economic activity (Yang and Doong, 2004: 147). Exchange rate movements can also affect economic activity. The inflationary impact of depreciation in the exchange rate creates distortions which can also hinder the allocation of resources (Mishkin, 2001).

While the impact of isolated volatility shocks is generally small, a source of concern is the correlation of market volatilities and associated spillover effects. Cross correlation of market volatilities is often related to common information that simultaneously alters expectations about returns in all the markets (Fleming, Kirby and Ostdiek, 1998:112). Information relating to fundamentals such as GDP, employment and inflation is expected to affect asset prices concurrently. Investment strategies such as cross market hedging that can enhance the linkages across the markets. When investors invest in the stock market and the money market, volatility in either market will influence their investment strategies. Investors will trade in each of the markets to protect themselves against the risk, thereby causing price movements to be highly correlated. Monetary policy through its links to the rest of the economy and asset prices has a significant impact on the financial markets. Thus monetary policy also provides another channel linking asset price movements and volatility (Mishkin, 2001:1-3).

Volatility co-movement can also arise when there are common shocks affecting the markets concurrently. According to this view, financial markets are subjected to external shocks that are not related to economic fundamentals. A shock in each of these external forces results in a coordinated rise in market volatilities. Belke *et al.*, (2003:2-4) argues that for developing countries faced with credibility factors, the sudden unavailability of foreign funds or a sharp reversal in capital flows can result in a sharp rise in both exchange rate and interest rate volatility.

Cross correlation of market volatilities is often related to the existence of spillovers, although correlation does not necessarily imply the existence of spillovers. Volatility spillovers are a source of concern because they can propagate volatility shocks across the market increasing the risk of a financial crisis. Therefore, understanding volatility co-movement and associated spillovers effects is crucial to the management and prevention of financial crises.

While policy makers and central banks generally agree on the need to promote financial stability, very little is still understood about the nature of financial instability - particularly the role of asset price volatility. In the past, policy makers and central bankers concerned with monitoring financial stability focused on the price stability and the stability of financial institutions, ignoring trends in asset prices. However, recent financial crises (for example, the East Asian crisis) and associated spillover effects have highlighted the weaknesses of such ignorance. An understanding of financial instability and cause of crises is important to prevent the occurrence of such a crisis of the magnitude of East Asia. In particular, the Asia crisis serves to remind policy makers of the importance of monitoring asset prices and the consequences of policy mis-steps (Radelet and Sachs, 1998:1). Understating financial instability will also improve the effectiveness of monetary policy, ensuring that monetary policies are directed at the source. In addition, given the impact of monetary policy shocks on asset prices, understanding the linkages between asset prices and monetary policy is crucial to ensure that monetary policy shocks are not an additional source of market risk.

The Asian crisis revived interest in examining and investigating financial instability. In its aftermath, numerous studies were carried out to examine its causes and impact. For example, Eichengreen (2004) examined financial instability in the region, while Radelet and Sachs (1998) and Corsetti^a *et al.*, (1999) examined the onset of the crisis and its causes respectively. Another group of studies focuses on the crisis prevention and management.

While a wealth of studies is available on the causes and impact of financial instability, very little empirical studies are available that model financial instability. In addition, the studies that are available focus on bank failures and currency crisis as manifestations of financial instability. Extensive research has been carried out to examine market volatility; however, the interaction of market volatilities and volatility spillovers remains an under researched area. For example, Engle and Ng (1993), Frommel and Menkhoff (2003) and Hillebrand and Schnabl (2004), Kaul and Sapp (2004) all focus on modelling volatility within a single market. The few studies that examine interaction of market volatilities restrict themselves to a single or two financial markets. None of them has examined the interaction of volatilities across the financial markets as a source of instability. For example Bala and Premaratne (2004) examine volatility spillovers across international stock markets while Yang and Doong (2004) examine volatility spillovers between the stock and foreign exchange market. These studies focus on developed countries, with developing countries receiving very little attention.

A similar study is the work of Rigobon and Sack (2003), which examined volatility spillovers across the US financial markets. However, Hurditt (2004) specifically focuses on asset price volatility as a source of financial instability in Jamaica. The study examines volatility spillovers across financial markets, with a special focus on volatility spillovers. Given the fact that very little research is available that focuses on developing countries, including South Africa, this study is an attempt to fill this gap.

1.1 THE OBJECTIVES OF THE STUDY

The main aim of this study is to model financial instability in the South African financial markets. In the literature, volatility and financial instability are often used interchangeably. While they are not strictly the same, they are related. As mentioned earlier, extreme asset price volatility could be an indicator of market instability. Even though they are not the same, in many studies of financial markets volatility is used to model financial market instability. Therefore a study of market instability is essentially a

study of market volatility. This will entail the estimation of market volatility and examining the trends and interaction across the markets to achieve the following objectives:

- to examine the long run trends in market volatility, to determine whether or not volatility is increasing or decreasing;
- to examine the volatility interaction among the markets so as to test for volatility spillovers;
- to identify the leading market, defined as the dominant source of volatility and hence market instability;
- to propose policy recommendations based on the findings.

1.2 THE METHOD OF STUDY

An in-depth review of literature is undertaken to lay the foundation for the analysis. To estimate market volatility the Autoregressive Conditional Heteroskedasticity (ARCH) model is employed. Different variations of the ARCH model can be employed to model market volatility. For example, the Generalised ARCH (GARCH), Threshold ARCH (TARCH), the Exponential GARCH (EGARCH) and the GARCH in mean (GARCH-M). The GARCH model is the most popular model, although it has its own limitations. The major limitation of the GARCH is the fact that it cannot account for leverage effects. Leverage effects are a common feature of stock returns and thus cannot be ignored. Thus the choice of the model that is employed is guided by features of the data. In this study, the choice of the model that is employed is guided by the unique features of each of the markets. The study will experiment with the different models and select the model that best captures the properties of the data.

To examine volatility trends, a combination of graphical analysis and trend analysis is used. Simple graphs are plotted to compare volatilities across the markets, while volatilities are regressed against a time parameter to determine whether or not market

volatility is increasing or decreasing. To examine the interaction of market volatilities, the multivariate Vector Autoregressive (VAR) model is employed. This analysis provides some insight into the propagation mechanism within the market that is a major source of systemic risk and hence financial instability.

This study utilises weekly data of stock prices (the all share index), exchange rates (the nominal rand dollar exchange rate), and interest rates (three month treasury bill rate). While the data sample spans the period from January 1996 to July 2006, the data used depends on the availability during this period. All data is sourced from Inet and Bloomberg.

1.3 ORGANISATION OF THE STUDY

The study is organised as follows: Chapter two presents the conceptual and theoretical framework for the study, while chapter three reviews the empirical evidence that supports the theoretical literature.

Chapter Four examines the long run movements of exchange rates, stock prices and interest rates. Chapter Five discusses the econometric models that are available to model volatility and volatility spillovers. 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 in chapter six; the chapter also discusses the results and implications of the findings. Finally, chapter seven provides a summary of the main findings, policy proposals and recommendations based on the findings.

CHAPTER TWO

CONCEPTUAL AND THEORETICAL FRAMEWORK

2.0 INTRODUCTION

This chapter discusses the conceptual and theoretical framework of the study. The first part of the chapter discusses the organisation of the financial system, specifically focusing on the major function of financial markets. These include raising capital for investment, price discovery and diversification of risk. The proper execution of this function is essential for financial stability and economic growth. However, financial markets suffer from an instability bias that can disrupt the operation of the markets (Crockett, 1997). Financial instability and its manifestations in various markets are the focus of the second part of the chapter. This part explores the major debates on the issue of financial instability, as well as the links between markets and the interaction of financial markets as a possible source of instability. Understanding the linkages between markets is important to understand the nature of instability and the conditions in which minor disturbances in a single market can lead to instability.

The chapter is organised as follows: section 2.1 discusses the organisation of financial markets; section 2.2 discusses financial instability, particularly focusing of the manifestation of instability in the financial markets; section 2.3 discusses the monetary policy transmission mechanism; section 2.4-2.6 discusses the theoretical links between financial markets and finally, section 2.7 concludes.

2.1 FINANCIAL MARKETS

2.1.1 Introduction

Financial markets provide the infrastructure and mechanism for the buying and selling of securities. 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. In terms of structure and organisation, financial markets can be broadly classified into the primary market and the secondary markets. This is a generic classification found in all the various markets. The markets can also be divided into the money market, the capital market (equity and bond markets) and the foreign exchange market (Faure, 2005:69). This section discusses the role and the organisation of financial markets. The first 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 second part discusses the various financial markets, functions and the actors involved in these markets.

2.1.2 Primary and secondary markets

In considering the role of financial markets, a distinction can be made between the primary and secondary markets. The primary market is the market where new securities are issued while the secondary market is the market where previously issued securities are subsequently traded (Faure, 2005).

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. 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). According to Mishkin (2003:23), the primary markets are something of a mystery to the general public because the selling of securities to initial buyers often takes place behind close doors, through private placement.

The secondary market consists of stock exchanges, whose regular business is the buying and selling of shares. This is the market in which previously-issued securities are subsequently traded. The secondary market is the more familiar of the two markets to the public, and when reference is made to the financial markets people are often referring to the secondary market. Although the life of most securities begins in the primary market, the secondary market is very important since it serves as a reference for the pricing of new securities. The secondary market also provides liquidity and is an indicator of the markets' readiness to receive new securities. Therefore, for the primary market to function efficiently, it relies on the secondary market for liquidity. Liquidity is the speed at which a security can be converted into cash; it requires marketability, market depth and price continuity (Goodspeed, 2004:11).

The most important function of the secondary market is the provision of an exit mechanism for most investors (Faure, 2003:84). Through the secondary market, investors can liquidate their investments or rebalance their portfolios as their investment objectives and their appetite for risk changes. The pricing of securities in the secondary market is determined by supply and demand and is therefore driven by the interaction between investors, speculators and arbitrageurs (JSE, 2005:10).

Certain securities such as equities trade on both the primary and secondary market. However, the majority of shares are traded on the secondary market (stock exchange). On the other hand, some securities are only traded on the primary market (over the counter). The foreign exchange market is the largest OTC market in the world. In this market, all the trade in currencies takes place through a network of foreign exchange dealers which are large banks situated around the world. Similarly, part of the derivatives market is mainly OTC driven. Even though some instruments like futures are traded on the exchange, the majority of derivatives, e.g., swaps, options, forwards are traded OTC (Faure,2005:69).

2.1.3 Types of financial markets

In addition to the primary and secondary markets, the financial system can also be divided into the specific markets that make up the system. The specific markets in the financial system include the money market, the bond market, the equity market and the foreign exchange market. These markets will be discussed in detail below.

2.1.3.1 The money market

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. According to Mishkin (2003:23), another way to distinguish the money market is in terms of maturity. The money market is the market for the issuing and trading of debt securities with a maturity of one year or less. Money market securities include bankers' acceptances, negotiable certificates of deposit and treasury bills.

On the other hand, Faure (2005:22) argues that the money market is much more than simply a market for short-term securities. The money market embraces the deposit market between banks themselves and between the banks and the central bank and the market for short term debt securities. The deposit market includes the private bank to bank deposit market, the private bank to central bank deposit market and the various significant operations of the central bank in this and other markets. The central bank operates in the money market in the form of open market operations. This is done to establish a certain desired "money market shortage", which is the level of borrowed reserves, and these reserves are provided at the central bank's accommodation rate, which is currently known as the repo rate (Faure, 2005:22).

The significance of the money market rests with the market's ability to act as a reference point for interest rates on all financial securities. The central bank, through its operations in the money market, is able to influence market rates such as call deposit rates and

ultimately, commercial deposit rates and lending rates. The money market's rates therefore make up the short end of the yield curve. 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).

2.1.3.2 The bond market

Taken together, the bond and money markets constitute the debt market. The bond market is the market for the issue and trade of long term debt instruments. Bond securities include government bonds (the majority of issued bonds), corporate bonds and debentures. The bond market can be seen as an extension of the money market, i.e. as the long end of the debt market. While short term interest rates are established in the money market, interest rates on long term securities are established in the bond market. Another way of seeing this is that money market rates make up the short end of the yield curve and bond rates the long end (Faure, 2005:22). The bond market therefore cannot be seen in isolation from the money market.

2.1.3.3 The equity market

Closely allied to the debt market is the equity market which, with the bond market, constitutes the capital market. This is the market where firms can raise capital and obtain long term funds. According to Faure (2003:84), "the economic benefit and function of the primary equity market is to channel surplus funds into productive investment at a price that is commensurate with the risk assumed by the buyer of the equity. The secondary market not only provides an exit mechanism for the investment (many investors invest only for the short term), but also provides real clues as to the correct pricing". Correct pricing and valuation of shares is crucial in the stock (equity) market (Faure, 2003:84).

2.1.3.4 The foreign exchange market

A discussion of the financial system would be incomplete without the foreign exchange market. According to Faure (2003:21), although the foreign exchange market is not a financial market, it is often associated with financial markets because it serves as a conduit for foreigners to local financial markets. Faure (2003:21-22) argues that since residents are able to borrow or lend offshore, and foreign investors are able to lend to or borrow from local institutions, the foreign exchange market has a domestic and foreign lending (or borrowing) dimension, and can be viewed as being closely allied to the domestic financial market.

2.2 FINANCIAL INSTABILITY

2.2.1 Introduction

Although it is generally accepted that financial instability is harmful to the economy, there is, however, still a lot of confusion surrounding the subject, and this has stimulated much debate among central bankers, economists and policy makers. The debate is centred on the definition of instability, its causes, its measurement, and the regulation of financial markets to prevent instability. These issues are discussed below.

2.2.2 Financial instability defined

Traditionally, financial instability is defined in relation to the failure of financial institutions, the incidence of financial crises and the resultant welfare losses associated with such crises (for example, see Eichengreen, 2004). Although institutional failures are not common, when they do occur they can cause major disruptions in the financial system. According to Lai (2002:1), financial crises are manifestations of financial system instability that impose a cost on the real economy. "A financial crisis is the occurrence of

a systemic event in the financial system, which is defined as an event that will trigger a loss in economic value or confidence in a substantial portion of the financial system that is serious enough to have significant adverse effects on the real economy” (Lai, 2002:1). According to the IMF (2003:63), periods of financial instability entail “severe market disruptions by impairing the system’s ability to provide payment services, to price and transfer risk and allocate credit and liquidity and have the potential to cause a reduction in real activity”. Financial system instability is often linked to concerns about the failure of key institutions (such as banks), although concerns about the overall liquidity and infrastructure of the financial markets can also prevail (Lai, 2002).

While the traditional definition is useful, it is limited in the sense that it does not make reference to asset prices. Sharp declines in asset prices can result in a reduction in net worth leading to debt defaults and bankruptcies. These institutional problems can threaten the stability of the financial system and precipitate crises¹. As a result of the correlation between asset price declines and institutional failures, policy makers have become aware of the importance of monitoring asset prices movements. This can be seen in the shift in monetary policy towards financial stability, which includes stability of key financial institutions and price stability. For example, according to the SARB (2004:3), in addition to the failure of financial institutions like banks, financial instability manifests itself through asset price volatility, extreme losses of liquidity in the market and a disruption in the settlement system. The shift towards asset price volatility is also evident within the literature where recent definitions of financial instability make reference to asset prices. For example, Lai (2002:2-5) notes that in addition to liquidity problems caused by problems in major financial institutions, the source of disturbances can be in the form of intense asset price volatility, or an asset bubble and the subsequent bursting of such a bubble.

For the most part, the impact of volatility is minor; however, in certain cases the disturbances can be severe enough to lead to a full blown financial crisis. According to the IMF (2003:63) periods of instability are nearly always accompanied by greater

¹ see Corsetia et al., (1999) and Radelet and Sachs (1998).

market volatility; however, market volatility need not imply instability since volatility will often have small consequences and need not always be the concern of the monetary authorities. When markets are efficient, prices embody all available information; therefore, asset price volatility will reflect the changes in economic fundamentals as investors react to such changes. Thus, while volatility is an inherent part of a well functioning financial system, it is only when it becomes extreme that it can put strains on key financial institutions and cause a rapid decline in asset prices, which is associated with financial instability concerns (IMF, 2003:63). In some cases, however, volatile asset prices have been cited as one of the major cause of the most recent financial crises. The example of East Asia is useful in this regard, since the instability that escalated into a fully-blown crisis was started by massive declines in stock, foreign exchange markets and real estate prices (Browne, Hellerstein, and Little, 1998).

Financial instability can manifest itself in many different ways. In the foreign exchange markets, instability is evidenced by volatile exchange rates and currency devaluations. In the money markets, instability is evidenced by liquidity shortages, interest rate volatility or the failure of a major financial intermediary. Stock market bubbles and declines as well as wild volatility of stock prices are obvious signs of instability in the capital markets (Crockett, 1997). While financial instability can manifest itself in many ways, for the purpose of this study financial instability will be defined as a manifestation of severe asset price volatility.

2.2.3 The causes of financial instability

The financial system is continuously subject to shocks and disturbances. These shocks can occur separately or can interact to cause instability. The IMF (2003:64) distinguishes between two types of shocks: broad or systemic shocks and idiosyncratic shocks. While systemic shocks affect a large part of the financial system and are caused by changes in the country's macroeconomic performance, idiosyncratic risks affect financial institutions and are related to changes or sudden drops in the price of a particular asset, caused by a

correction in misalignments (for example a bubble). In addition, certain financial practices, for example leverage trading and hedging activities, encourage excessive risk-taking, increasing the risk of instability. As noted in section 2.2.2, disturbances are natural features of the system and on their own do not necessarily cause a crisis. However, the systemic occurrence and interaction of these events is essential for the development of financial instability. Moreover, the degree to which shocks to the financial system are amplified and propagated across the markets or across institutions is the key element of financial instability (IMF, 2003:63).

The IMF (2003:64) identified the following factors that can aggravate price volatility, increasing the risk of wide spread instability in the market: incentive structures, lack of robust risk management, lack of transparency and market infrastructure weaknesses. These are summarised by the IMF (2003:64) and discussed below.

2.2.3.1 Incentive structures

Peer-group performance measures or index tracking can encourage herding among institutional investors, leading to amplified or self-perpetuating price movements. Pressures on investment managers to meet short term targets, or incentive structures that reward staff according to volume of business rather than risk-adjusted earnings can encourage excessive risk-taking and reckless leveraging. The conflict of interest that exists between investment managers and investors can also lead to insufficient disclosure of risks. Another source of instability is sudden changes in herd instinct caused by an increase in leveraging (IMF, 2003: 64).

2.2.3.2 Lack of robust risk management

Leveraging increases the sensitivity of financial institutions and the system as a whole to economic downturns and asset price declines. Highly leveraged firms can experience an appreciation of risk if this is not factored into risk management principles. In addition, if

currency mismatches are not factored into risk management principles, they may lead to systemic risk, especially in cases of a pegged exchange rate where the possibility of regime change is not factored into risk management. Finally, certain hedging strategies by managers, for example the unwinding of concentrated leveraged positions, can also increase volatility. A combination of these factors, extreme price movements and sudden appreciation in market credit risk, can lead to heavy losses in key institutions and disruption in market pricing (IMF, 2003:64).

2.2.3.3 Lack of transparency

Lack of disclosure of positions by individual firms complicates risk management by others under volatile conditions. At the same time, inadequate initial disclosure of positions can lead to sudden changes in market sentiment when the positions are eventually disclosed. Market uncertainty over the solvency of an institution and the safety of other institutions can also impair the payment system and reduce liquidity (IMF, 2003:64).

2.2.3.4 Market infrastructure weaknesses

Failures in the payment and clearing systems can cause payment problems. Payment problems are problematic because a single default can compromise the integrity of the payment system as a whole, causing widespread panic. Therefore, the appropriate balance between market discipline and regulation needs to be found (IMF, 2003:64).

2.2.4 Regulation of financial markets

Financial instability brings to the fore issues about the regulation of financial markets. Effective regulation will improve market efficiency while removing the incentives for excessive risk-taking. Although there is agreement that financial institutions should be

regulated, there is no consensus as far as financial markets are concerned. Those in favour of free markets argue that they are efficient and that state intervention should be limited to correcting market failures. However, Crocket (1997:20) argues that financial markets can be subject to instability bias which can escalate into a crisis. In addition, he argues that instability can spread to other parts of the financial system via contagion. Therefore he concludes that regulation and monitoring of financial markets is crucial to prevent the occurrence of instability. Further, while Crocket (1997:8) advocates financial regulation, he asserts that the potential for contagion across markets and countries should provide a guide as to what markets are important and therefore should be regulated. For example, the securities market through its links to the rest of the economy is a potential source of contagion. On the other hand, the foreign exchange market can be a channel for the international transmission of shocks.

Regulation of financial markets should be aimed at improving efficiency rather than directly regulating the movement of prices. Markets should be regulated to prevent the build up of inefficiencies while allowing enough flexibility for markets to operate efficiently (Crockett, 1997).

2.2.5 Measuring financial instability

There are several approaches to measuring volatility of asset prices. The simplest approach is using the standard deviation which, until recently, has enjoyed widespread application. Other methods include the historical measure, implied volatility models and the exponential weighted moving average models (EWAM). While these methods provide useful estimates of volatility, they fail to capture the unique properties of financial data².

In view of the limitations of such measures, sophisticated volatility models have been developed. Examples of such models are the autoregressive conditional

² These include autocorrelation of returns, non-normality implying that returns have excess kurtosis and are leptokurtic (Brooks, 2003: 445-446).

heteroskedasticity (ARCH) and the generalised ARCH (GARCH), which have been applied particularly to model volatility of financial data. The ARCH/GARCH models provide useful estimates of volatility that capture the unique properties of financial data. Recent applications of the ARCH/GARCH models include empirical work of Hillebrand and Schnabl (2004), Brooks and Raganathan (2003), Frommel and Menkhoff (2003), and Rigobon and Sack (2003), who employed conditional heteroskedasticity models to measure volatility of asset prices.

2.3 FINANCIAL MARKETS AND INSTABILITY: INTERACTIONS AND LINKS

2.3.1 Introduction

Financial markets fulfil a vital role in the financial system; however, they can also be a source of disturbance to the financial system and the economy. The very nature, operation (margin trading, inter bank claims) and the organisation (centralised trading, national payment system) of financial markets makes them inherently unstable and vulnerable to adverse shocks (Crockett, 1997). The presence of links between the different markets could provide a channel for the propagation of shocks leading to a crisis. Thus, understanding these linkages is crucial to designing effective policies to manage financial crises. This section discusses the theoretical links between each of the markets.

2.3.2 Monetary policy

One way of understanding the link between exchange rates, stock prices and interest rates is via the relationship of each of these variables to monetary policy. A monetary policy shock that changes interest rates has a direct impact on exchange rates by affecting capital flows. In addition, changes in interest rates also have an impact on asset prices by

altering the discount rate which is a crucial input in asset pricing (Faure, 2003:250). Therefore, in order to understand the interaction between changes in exchange rates, stock prices and interest rates, it is crucial to understand what drives interest rates.

While it is generally accepted that interest rates are market-determined, in reality the central bank has a direct influence on market interest rates through monetary policy. In most countries, the central bank influences market rates through an administratively determined official bank rate (the rate at which the central bank lends to commercial banks). This policy is only effective when banks are forced to borrow from the central bank (Faure, 2003:236).

In South Africa, the South African Reserve Bank (SARB) always ensures that the banking system has negative excess reserves, meaning that the banks at all times borrow from it. The official bank rate (in South Africa currently known as the repo rate) represents the cost of money to the banks. Since this is the highest call or short-term money rate in the money market, banks will try to avoid borrowing from the central bank and rather borrow in the inter-bank market. Competition among the deficit banks for surplus reserves will drive the inter-bank rate upwards close to the central bank rate. This system will ensure that inter-bank rates are always close to the repo rate (Faure, 2003:236). To understand the impact of changes in interest rates on exchange rates and stock prices, a useful starting point is the monetary policy transmission mechanism (MPTM). This traces the channel through which changes in the official rate (repo rate) affects market rates, and ultimately exchange rates and stock prices.

2.3.3 Monetary policy transmission mechanism

The monetary policy transmission mechanism (MPTM) describes the channel through which changes in monetary policy (official interest rate) are transmitted throughout to ultimately affect inflation and aggregate output. To illustrate the effect of monetary policy on exchange rates, stock prices and interest rates, let us assume that the central

bank implements an expansionary monetary policy by adjusting the official rate downwards (reduction in the repo rate). While monetary policy is aimed at inflation curbing, changes in interest rates have an impact on exchange rates, stock prices and other asset prices. Faure (2003:236) describes the monetary policy transmission as follows:

Stage 1: Transmission from the central bank rate to the inter-bank rate

At the end of each business day, when official clearing and settlement takes place, deficit banks will seek to obtain funds from the surplus banks. As noted earlier, competition among deficit banks will keep the inter-bank rate between private banks close to the repo rate. Thus, the first rate that will be affected by a reduction in the repo rate is the inter-bank rate, which will decline accordingly. This can be represented schematically as follows:

Central bank rate ↓ > inter-bank rate ↓

Stage 2: Transmission from inter-bank rates to other market rates

The central bank repo rate and the inter-bank rate have a powerful influence on short term and long term rates. The shortest rate in the market is the call money rate, which is directly affected by the central bank rate and the inter-bank rate. The call money rate represents wholesale rate that is charged on overnight money. The call money market is the domain of pension funds, insurance companies and banks that seek large sums of money on short notice. Banks are involved in the call money market, as well as the securities market as broker dealers or holders of securities. According to Faure (2003:243-244), securities are borrowing (i.e. debt) instruments, and the rates on them are borrowing rates (from the point of view of the borrower – and a lending rate from the point of view of the lending banks). Thus, as lending rates increase, so do borrowing rates, because lending is the counterpart of borrowing.

The call rate represents a deposit rate for the lending bank and a borrowing rate for the borrowing bank. Therefore, changes in the call rate will also result in changes in

commercial banks' deposit and lending rates in the same direction. Therefore, banks will adjust their prime rate, which causes all other bank rates to change in the same direction. The effect of a reduction in the official rate on market rates can be illustrated as follows:

Central bank rate ↓ > inter-bank rate ↓ > call money rates ↓ > market rates ↓

Stage 3: Transmission from market rates to asset prices

Interest rates are a crucial input into the pricing of stock and other financial instruments like options. A fall in interest rates will reduce the discount factor in the formula for valuation of stocks, thus leading to an increase in stock prices. In addition, changes in short-term rates will also lead to changes in medium- to long-term rates in the same direction. This will also cause treasury bill and bond rates to change in the same direction, leading to an increase in bond prices. Consequently, the effect of a fall in interest rates will be an increase in asset prices.

Changes in interest rates also have an impact on exchange rates. Interest rates are a major driving force behind capital inflows and outflows. High interest rates will increase the relative return of domestic debt and thus stimulate capital inflows. Conversely, lower interest rates discourage capital inflows or lead to outflow of capital because of decrease in the return on domestic debt. The effect of a reduction in interest rates on asset prices and exchange rates can be represented schematically as follows:

Central bank rate ↓ > inter-bank rate ↓ > call money rates ↓ > market rates ↓ > asset
prices↑ > exchange rates ↓

The monetary policy transmission mechanism does not end here. Changes in interest rates will affect aggregate demand and ultimately output and inflation. However, for the purpose of this study, the discussion up to this point will suffice. From the discussion of the MPTM, it becomes clear that monetary policy exerts a powerful influence on exchange rates and asset prices. In addition, the effect of a decline in the official rate will be a rise in asset prices and an increase in the exchange rate (depreciation). Therefore,

interest rates are negatively related to asset prices and exchange rates. This forms the basis on which the relationship between exchange rates, interest rates and asset prices will be discussed.

The next section will extend this basic framework to examine the interaction between stock prices and exchange rates, stock prices and interest rates, and finally between exchange rates and interest rates. The interaction of their volatilities will also be discussed.

2.4 STOCK PRICES AND EXCHANGE RATES

According to Fang and Miller (2002:1) when investors invest in both domestic and foreign markets, they have to consider how movements in the currencies will affect their expected stock returns. Thus, exchange rate risk (volatility) provides an additional channel through which an asset's expected return trades off with exchange rate volatility (Fang and Miller, 2002:1). On the other hand, short term portfolio flows affect the level of exchange rates. Since stock and debt investments constitute a large part of portfolio investments, policy makers have to take into consideration how movements in stock prices will affect exchange rates (Fang and Miller, 2002:1).

In their study of the relationship between the stock market and the foreign exchange market in Malaysia, Huzaimi and Liew (2004:2-4) identified two main approaches: the traditional and the portfolio approaches. These approaches describe the channels through which changes in the exchange rates are transmitted to stock prices and vice-versa. The two approaches are discussed in greater detail below.

2.4.1 The traditional approach

According to the traditional approach, the appreciation (or depreciation) of a local currency has two major implications. Firstly, it will decrease (or increase) indebtedness in terms of foreign currency denominated debts. In other words, outstanding debts of local companies will be worth less (or more) and thus they will have to pay less (or more) in terms of the domestic currency. As a result, companies' cash flows will improve (or deteriorate). Secondly, companies that rely heavily on imported inputs in their production activities will experience a decrease (or increase) in production costs. According to Huzaimi and Liew (2004:3-4), one of the consequences could be a gain (or loss) in price competitiveness and the companies' revenues. The net effect will be an increase (or decrease) in companies' net worth and stock prices. This approach is especially true in the case of developing countries whose debts are denominated in foreign currency. In this view, changes in exchange rates will lead to changes in stock prices; therefore, the causality should run from foreign exchange market to the stock market.

Secondly, the traditional approach posits a positive correlation between changes in exchange rates and stock prices (appreciating exchange rates improves balance sheets and raises stock prices), implying that stock prices and exchange rates move together. To the extent that fluctuations in exchange rates cause fluctuations in cash flows, market uncertainty will increase, thus causing fluctuation in stock prices (Huzaimi and Liew, 2004:3-4).

2.4.2 The portfolio approach

The portfolio approach emphasises the centrality of the role of the capital account and movement in assets across borders. Here, exchange rates are like any other commodity where the price is determined by market demand and supply forces. Rising (or falling)

stock prices will attract (or discourage) capital inflows from foreigners seeking high returns, who sell the foreign (local) currency in return for local (foreign) currency. Therefore, capital inflows (outflows) will lead to an appreciation (or depreciation) of the exchange rate. The increase (or decrease) in stock prices will have additional effects by increasing (or decreasing) the wealth of domestic investors, thereby increasing (or reducing) the demand for local currency and subsequently pushing up (or down) the local interest rates. The higher (or lower) interest rates will encourage more capital inflows (outflows), resulting in a further appreciation (or depreciation) of the currency (Huzaimi and Liew, 2004:4). According to this approach, changes in stock prices will lead to changes in exchange rates; therefore causality should run from stock prices to the foreign exchange market. The portfolio approach also predicts a positive correlation between stock prices and exchange rates, meaning that fluctuations in stock prices will result in fluctuation in exchange rates in the same direction.

While the two approaches differ on the issue of causality they both, however, predict a positive volatility relationship. A variable exchange rate creates uncertainty in returns for foreign investors. On the domestic front, a variable exchange rate will lead to earnings uncertainty, negatively impacting stock prices. This uncertainty will be reflected in increased trading activity, as foreign investors attempt to liquidate their positions and domestic investors attempt to hedge against the anticipated price volatility. Therefore, volatile exchange rates will induce volatile stock prices. Likewise, volatile stock prices will increase uncertainty for both foreign and domestic investors. Foreign investors are generally more sensitive to market uncertainty. Therefore, instability in the local stock market usually causes capital outflows, inducing fluctuations in the exchange rates. In practice investors will hedge their exposure to market risk, generating trading and volatility in both markets. The hedging strategies of investors imply a negative volatility relationship.

2.5 STOCK PRICES AND INTEREST RATES

As noted earlier (see the discussion of the monetary transmission mechanism), interest rate shocks are the counterparts of a monetary policy shocks. In addition, changes in market yields are highly correlated with changes in the official rate. In this discussion, 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 relative to stocks. A fall in interest rates will therefore increase the demand for stocks, pushing up the price of stocks. On the other hand, a contractionary policy (an increase in interest rates) leads to an increase the demand for debt securities and a fall in the demand for stocks and stock prices. The relationship between the two markets arises from this trade off.

According to Mishkin (2001:1), the transmission mechanisms involving the stock prices and interest rates are of three types: (1) stock market effects on investment, (2) firm balance-sheet effects, and, (3) household liquidity and wealth effect. These will be discussed briefly below.

Stock market effects on investment: Tobin's (1969) theory forms the background for this channel³. Following Tobin's q theory, an increase in stock prices (as a result of reduction in interest rates) will raise q and thus increase investment expenditure. Although in Tobin's theory higher stock prices will lead to an increase in fixed investment, it can also increase portfolio investments. Firms with a high net worth can acquire stock in other firms as well as initiate a takeover bid, pushing stock prices up. Therefore, to the extent that higher investments are in the form of take over bids and acquiring stakes in other firms, it will lead to an increase in stock prices (Mishkin, 2001:1-3).

Firms' balance sheets and liquidity: These provide an additional channel that links stock prices and interest rates. Higher stock prices increase the net worth of firms, reducing the incentive to undertake risky projects. Since net worth constitutes collateral for borrowing

³ In Tobin's theory q is defined as the market value of firms divided by the replacement cost of capital. If q is high the market value of firms is high relative to the replacement cost of capital, making plant and equipment cheap relative to the market value of firms. Companies can then issue stock and receive a high price relative to the cost of facilities and equipment that they are buying. Investment spending will rise because firms can buy a lot of new investment goods with only a small issue of stock

purposes, higher net worth will reduce adverse selection and moral hazard. In the absence of adverse selection and moral hazard, banks will be more willing to lend to firms, increasing investment and stock prices.

Household balance sheet: This provides the last channel linking stock prices and interest rates. Households hold a portfolio of liquid asset (stocks, bonds and cash) and illiquid assets (durable goods) in their balance sheets. Households' expectations of financial distress will influence how much of each asset class to hold in their balance sheet. If their expectations of financial distress are high, they will hold more liquid assets and vice-versa. Expansionary monetary policy will increase stock prices, reducing the expectation of financial distress and thus increasing expenditure on consumer durables. High consumer spending will increase retail sales, increasing revenue and earnings, further pushing stock prices up.

The interest rate channel shows that changes in interest rates lead to changes in stock prices, implying that causality will run from interest rates to stock prices. This channel predicts a negative correlation between stock prices and interest rates. The negative correlation between market returns gives rise to the benefits of cross market hedging. Changes in market returns due to monetary policy shocks will induce investors to rebalance their portfolios in an attempt to reduce portfolio risk, generating trading and volatility in both markets (Fleming, Kirby and Ostdiek, 1998:112).

The outcome of the volatility relationship will depend on the monetary policy regime. When monetary policy is transparent, changes in interest rates will not come as a shock to financial markets and stock prices will be stable. However, when interest rates changes come as a surprise to investors and financial market participants, it can induce a large jump in stock prices. A transparent monetary policy is usually associated with less frequent interest rate shocks (low volatility) since monetary policy (under transparency) will have the desired effect on inflation (Faure, 2003). Conversely, when the central bank has low credibility and monetary policy is not transparent, interest rates will be volatile, inducing stock prices volatility (Belke *et al.*, 2003).

Thus far, the discussion has focused on the response of stock prices to a shock in interest rates. On the other hand, monetary policy also responds to movements in stock prices. In the past, central banks were not generally concerned about asset price volatility. However, recent asset price bubbles and the subsequent bursting of such bubbles have caused central banks to become concerned about the effect of volatile asset prices on the economy (Mishkin, 2001:11). Although stock market fluctuations are usually mild, severe price volatility can adversely affect investment and aggregate demand (IMF, 2003:62-63).

In spite of the adverse effects of stock market fluctuations on the economy, policy makers are still reluctant to explicitly target them. Mishkin (2001:15) argues that targeting stock prices would present serious problems which include the following: firstly, to target stock prices, policy makers would need the expertise to identify asset price bubbles if and when they occur. Secondly, since stocks are very volatile, monetary policy would fluctuate frequently, causing a lot of uncertainty in the market. Thirdly, the volatile nature of asset prices means that the probability of making an error is high; a mistake on the part of the central bank would weaken credibility, making monetary policy ineffective. Central to the success of inflation targeting is the certainty about the likely reaction of central bankers to inflation.

Central banks respond to stock prices only in so far as they affect aggregate demand and inflation. The question now is how can a rise in stock prices be inflationary? Modigliani's (1971) (see Mishkin, 2001:4) life cycle model states that consumption is determined by lifetime resources of consumers. Stocks and financial assets constitute a large part of consumers' lifetime resources. Therefore, a rise in stock prices raises the value of household's wealth, increasing the household's lifetime resources, leading to a rise in consumption expenditure. A rise in consumption expenditure will increase aggregate demand thereby increasing inflation. High inflation will induce central banks (that are concerned about maintaining a low rate of inflation) to increase interest rates. A one time shock to stock prices will lead to a one time rise in interest rates. However, if a bubble

follows, the result may be more rate hikes. Therefore, volatile stock prices can lead to volatile interest rates. It is important to note that in this case, monetary policy is targeting inflation and not stock prices. Interest rates will only be increased when the rise in stock prices is inflationary (Mishkin, 2003: 15-16). Generally, the central bank will not react to asset price volatility, making this channel weak. Hence, on the relationship between interest rates and stock prices volatility, it is expected that causality will predominantly run from interest rates to stock prices (Mishkin, 2003: 15-16).

2.6 EXCHANGE RATES AND INTEREST RATES

The theoretical approach to exchange rate and interest rates is based on the uncovered interest rates parity theory (UIP). According to the UIP, exchange rates will move to equalise the relative returns of domestic and foreign bonds (Appleyard, Field, and Cobb, 2006). A fall in interest rates following an expansionary monetary policy will reduce the return on domestic bonds, thus making them less attractive relative to foreign bonds. A fall in the relative return on domestic bonds results in a fall in the demand for bonds, causing a depreciation of the currency (Mishkin, 2001: 7). The theoretical approach describes the channel through which changes in interest rates are transmitted through the economy to ultimately affect the exchange rate. This channel is also referred to as the fundamental view, because it emphasises the role of economic fundamentals as a driver of exchange rates. The theoretical approach implies a negative relationship between exchange rates and interest rates.

The interest rates channel describes the response of exchange rates to a monetary policy shock, implying that causality runs from changes in interest rates to changes in exchange rates. However, when exchange rates float freely, fluctuations in exchange rates are likely to elicit a response from monetary authorities in an attempt to stabilise exchange rates, causing interest rates to respond to fluctuations in exchange rates. The extreme case of targeting exchange rates would result in interest rates fluctuating as often as changes in exchange rates (Mishkin, 2001).

In general, monetary policy does not target exchange rates; the level of exchange is monitored to guard against unfavourable movements in exchange rates that may have adverse effects on output and inflation. Central bankers and policy makers are concerned about both the appreciation and the depreciation of a currency. A depreciating currency might lead to higher inflation due to the pass-through from higher import prices. Conversely, an appreciating currency will raise the price of exports, thus making them less competitive. In both cases, if the movement in the exchange rate is sharp enough, central banks will be under pressure to respond. In addition, businessmen, politicians and the general public keep a watchful eye on movements in exchange rates, putting more pressure on authorities to respond to sharp movements (Mishkin, 2001: 10).

Generally, central banks respond to sharp movements in exchange rates insofar as the changes are inflationary or will lead to a reduction in the competitiveness of domestic industries. A depreciating currency will call for a rise in interest rates while an appreciating currency will invite a fall in interest rates. According to Mishkin (2001:11), the offsetting effect of interest rates and exchange rates on inflation depends on the nature of the shock. If the shock to exchange rates comes from a portfolio shock, the resulting effect will be a rise in inflation. However, a depreciation caused by terms of trade shocks as a result of a demand shock is likely to be deflationary. Since a demand shock will have a contractionary effect on the economy, the correct response to a depreciating currency in this scenario will be to reduce interest rates. When there is a terms of trade shock, it is clear that targeting exchange rates would lead to an incorrect response.

On the other hand, targeting exchange rates would make monetary policy highly erratic, creating instability in the market. In this environment, exchange rate volatility will lead to uncertainty about the response of monetary policy and thus further increase uncertainty, which can cause investors to withdraw their funds, further heightening interest rate volatility. This suggests that targeting inflation or an intermediary target like money supply would produce a more optimal outcome in terms of stable and predictable monetary policy (Mishkin, 2001:12-14).

The interest rate and the exchange rate channels predict a negative correlation between interest rates and exchange rates. Higher interest rates lead to an appreciation in the exchange rates and vice-versa, while depreciation in the domestic currency will lead to a rise in interest rates and an appreciation leading to a fall in interest rates. Although in theory interest rates are expected to rise to offset depreciation or fall to offset an appreciation, the nature of the shock will also determine the response (Mishkin, 2001: 11). When exchange rates fluctuations are caused by portfolio shocks, interest rates will rise to offset depreciation, bringing about a negative correlation between exchange rates and interest rates. Alternately, terms of trade shocks lead to a positive correlation between exchange and interest rates.

With regard to the volatility relationship when exchange rates are the target, exchange rate volatility will lead to volatile interest rates. The extreme case of targeting exchange rates is the so called “fear of floating”, where central banks are reluctant to allow their currency to float (Belke *et al.*, 2003:1-2). In this case, monetary policy will be highly erratic since interest rates will be adjusted to mitigate fluctuations in the exchange rates. According to this view, there exists a volatility trade-off between exchange rates and interest rates. A more stable exchange rate can only be achieved by allowing fluctuations in monetary policy and vice versa (see for example Reinhart and Reinhart (2001), in Belke *et al.*, (2003:1-2)).

Although the above represents the conventional view, other authors argue that in developing countries, exchange rates and interest rates volatility move together, implying a positive correlation in volatility. For example, Belke *et al.*, (2003:4) assert that exchange rates and interest rates volatility in developing countries are driven by similar factors which may cause them to move together. These include developments in international financial markets, availability of financing, capital inflows and reputation. An external shock like the sudden unavailability of foreign financing can cause both exchange rates and interest rates to shoot up. Accordingly, these credibility factors may cause exchange rates and interest rates to move together.

Lahiri and Vegh (2001:2-3) argue that when developing countries have a “fear of floating”, exchange rates and interest rates can move together over time. The authors develop a theoretical model of exchange rate variability. In this model, the fear of floating stems from the fact that exchange rate variability causes disruptions in the economy that may result in output losses. In the presence of nominal wage rigidities, a depreciating (or appreciating) exchange rate will reduce (or raise) the real wage above the equilibrium level and lead to voluntary (involuntary) unemployment. In this case, a movement in either direction (appreciation and depreciation) is disruptive.

On the other hand, a variable interest rate creates uncertainty which can discourage investment causing a contraction in output. Although high interest rates increase demand for domestic liquid assets and stimulate the currency, high interest rates will discourage investment by increasing the cost of borrowing. The model is applied to developing countries that experience a negative money demand shock that leads to a depreciation of the currency. In this instance, policy makers will be faced with the choice of increasing interest rates to defend the currency or intervening in the foreign exchange market by selling reserves. According to Lahiri and Vegh (2001:4), the optimal policy response to a negative money demand shock is a function of the size of the shock. If the shock is small, the optimal policy response is not to intervene and allow the exchange rate to depreciate. However, since exchange rate fluctuations impose output costs, interest rates should be increased to offset the shock. When the shock is large, exchange rate fluctuations will impose significant costs to output. In this case, it is optimal for policy makers to intervene with the full amount that is required to prevent the exchange rate from depreciating.

Lahiri and Vegh (2001:4-5) further argue that if the world is envisaged as a sequence of monetary shocks (developing countries facing the most) the model will predict the following: developing countries would exhibit low exchange rate variability and high variability in reserves. In contrast, developed countries will exhibit high exchange rate volatility and low reserve volatility. They argue that for countries that are hit by negative

money demand shocks, on average one would observe a response that consists of falling reserves, a more depreciated currency and higher interest rates. Thus, the correlation between changes in (1) exchange rates and interest rates would be positive; (2) reserves and exchange rate would be negative, as would (3) reserves and interest rates.

The credibility approach and the fear of floating approach hypothesise a positive correlation between exchange rates and interest rates. Accordingly, since the factors driving exchange rates and interest rates are external (beyond the control of monetary policy), both can shoot up at the same time. As far as the causality is concerned, this would imply that changes in exchange rates do not cause changes in interest rates or vice versa. In addition, although the two move together, they may well be independent of each other. Although the fear of floating and the credibility approach seem to be at odds with the traditional approach, they are important in developing countries. In this study, both approaches will be tested.

2.7 CONCLUSION

This chapter presented the conceptual and theoretical framework of the study. The first part of the chapter discussed the organisation of financial system, specifically focusing on the markets that comprise the financial system i.e. the money market, stock market and the foreign exchange market. The second part of the chapter discussed financial instability. Here the focus was on the definitions, causes and manifestations of instability, as well as issues of market regulation to prevent instability. An attempt was also made to define financial instability and, for the purpose of this study, it was noted that the focus will be on one aspect of financial instability - asset price volatility. A major part of this section was devoted to discussing the theoretical links across the markets. These links are the essence of the study, and will form the basis of the analysis. The next chapter reviews the empirical literature on the links between the markets.

CHAPTER THREE

EMPIRICAL LITERATURE

3.0 INTRODUCTION

Numerous studies have been carried out on the relationship between exchange rates and stock prices; stock prices and interest rates; and exchange rates and interest rates. For example, Thorbecke (1997) examined the effect of monetary policy on stock prices, and Huzaimi and Liew (2004) examined the relationship between exchange rates and stock prices. While literature is available on the relationship between these variables, very little empirical work has been carried out to examine the volatility relationship. In addition, most of the empirical studies that are available are based on advanced countries, with developing countries receiving very little attention. For example, 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.

However, in the aftermath of the major financial crises around the world, attention has shifted towards developing and emerging markets, with many researchers focusing on these markets. While many of these studies are aimed at examining trends in market volatility and the impact of volatility shocks on domestic financial markets, very little research focuses on the interactions of volatility across the markets. An exception is the study by Belke *et al.*, (2003) which examines the interactions of exchange rate volatility and interest rates volatility in MECOSUR countries (Argentina, Brazil, Paraguay and Uruguay). In view of the fact that little empirical evidence is available, the few studies that are available will be reviewed.

In general, empirical evidence on market relationships is inconclusive. While some authors find significant relationships, others found weak and insignificant links. Chiarella

et al., (2002:30) found evidence of an insignificant negative relationship between stock prices and interest rates, while Thorbecke (1997:635-654) found evidence of a statistically significant negative relationship between stock prices and interest rates. Rigobon and Sack (2002:15), on the other hand, found a strong response of stock prices to monetary policy shocks.

On the correlation between the stock market and foreign exchange market, Huzaimi and Liew (2004:13-14) found evidence of a significant relationship in Malaysia and Thailand. With regard to the volatility relationship, Yang and Doong (2004:147) found evidence of significant volatility spillovers between stock prices and exchange rates. Rigobon and Sack (2003a:14) found that both stock price and interest rate volatility respond to each other. Conversely, Belke *et al.*, (2003:23) found no evidence of a negative relationship between the exchange rate and interest rate volatility. As mentioned in chapter two, a negative correlation between volatilities would imply a volatility trade-off between exchange rates and interest rates. They argued that for countries that are exposed to speculative attacks and hyperinflation, exchange rate and interest rate volatility move together (positive correlation).

Although the results are inconclusive, these studies suggest that the variables may be related. The chapter is organised as follows: section 3.1 discusses empirical evidence on stock prices and interest rates; section 3.2 discusses exchange rates and stock prices; section 3.3 discusses exchange rates and interest rates, and finally, section 3.4 concludes the chapter.

3.1 STOCK PRICES AND INTEREST RATES

As noted in section 2.4.2, the relationship between stock prices and interest rates is based on the share valuation models like the Gordon constant growth dividend discount model. In this model, the interest rate represents the discount factor. Therefore, as the interest rate (discounting factors) increases, stock prices are expected to decline. Thus, the model

predicts a negative relationship between stock prices and interest rates. Alternately, the level of stock prices is positively related to output and inflation. As mentioned in section 2.6, higher stock prices increase aggregate demand and prices. If the aggregate demand shock is inflationary, the result will be an increase in interest rates. Thus, output provides another link between stock prices and interest rates.

Arango *et al.*, (2001) examined the relationship between the share prices on the Bogotá stock index and interest rates for the period January 1994 to February 2000. Their study aimed to test the hypothesis of a negative relationship between the two variables. Using the Johansen cointegration procedure, the results indicated a rejection of the hypothesis of a common trend between these two variables. An examination of the distribution of stock prices shows that stock prices follow a similar pattern to that of most financial data, in that relatively volatile periods characterised by large returns are accompanied by quiet periods of small returns. These features suggest the presence of non-linearity in returns. Given that non-linearity could not be rejected, a non-linear exponential threshold GARCH (ESTR-GARCH) model was estimated.

A change in interest rates (with a lag of 11) appeared in the linear model with the right sign, which evidenced a negative relationship between returns and interest rates. According to the authors, the model gave some evidence about the existence of a non-constant equity premium, which depended upon whether the nonlinearity was active or not. In addition, the ESTR-GARCH suggested that adjustments of returns towards the premium are symmetric. The autoregressive part (linear and nonlinear) of the ESTR-GARCH model could be associated with the fads⁴ component, which allows for share returns to deviate from the ones dictated by the fundamentals. The value of the interest rate coefficient was very low, even though it was significant. Further, the negative effect of interest rates on returns occurred after a long lag, which the authors argued could be caused by the agents waiting a few days to ascertain whether the interest rate shock was temporary or permanent before modifying their positions (Arango *et al.*, 2001:9).

⁴ Fads, also known as a craze, refers to a fashion that becomes popular in a short period of time but loses popularity quickly. In the stock market it refers to periods where stock prices are driven by fashionable trends rather than market fundamentals (Arango, *et al.*, 2003:8).

Changes in interest rates are directly related to monetary policy shocks. As mentioned in the previous chapter, monetary policy affects asset prices through the monetary policy transmission mechanism. Thus, the monetary policy transmission mechanism provides another channel linking the markets. Rigobon and Sack (2002) examined the effect of monetary policy on stock market indexes and yields over the period 3 January 1994 to November 26 2001. The stock market indices included the Dow Jones Industrial Average (DJIA), the S&P 500, the NASDAQ and the Wilshire 5000. The long term interest rates included in the sample were treasury yields with maturities of six months, one, two, five, ten and thirty years. For a more complete picture, euro/dollar futures rates expiring every three months from six months to five years ahead were also included. The short term interest rates used was the rate on three-month euro/dollar deposit at the time of contract expiration.

The authors employed an approach called identification through heteroskedasticity. This approach relies on looking at the changes in the co-movement between asset prices and monetary policy when the variance of one of the shocks in the system shifts. They assumed that the variance of monetary policy shocks was higher on days of monetary policy committee meetings and of the chairman's semi-annual monetary policy testimony to Congress, when a larger portion of the news hitting markets was about monetary policy (Rigobon and Sack, 2002:6). They showed that the shift in the variance of the policy shocks on those dates was sufficient to measure the responsiveness of asset prices to monetary policy. It is important to note that other types of shocks still took place on these days, but the relative importance of policy shocks was likely to increase dramatically, as required under the identification approach. Thus, the authors examined the shift in the variance of the monetary policy shock on the policy date and after the policy date (Rigobon and Sack, 2002:6).

In the model, the non-policy dates were taken to be the day before each policy date. As expected, the variance of changes in the short-term interest rate rose substantially on the days with higher variance of policy shocks. An examination of the co-variances showed

that for the non-policy dates, there was no discernible relationship between stock prices and the policy rate, as was evidenced by the relatively small co-variances between them (Rigobon and Sack 2002:14). In contrast, a negative relationship between these variables became evident on the policy dates, as the higher variance of the policy shocks on those days tended to move the observations along the asset price response function. In contrast, treasury rates had a positive co-variance with the policy rate on non-policy dates. However, the relationship between these variables shifted significantly on policy dates, with the positive co-variance jumping much higher in that sub-sample.

According to Rigobon and Sack (2002:2) there are two main problems associated with any study of the interaction between asset prices and interest rates. This is the problem of endogeneity and omitted variables. Endogeneity arises where the variables of interest are determined within the system. This occurs when interest rates affect asset prices, with asset prices also affecting interest rates. This can also arise when there is a missing variable that jointly affects both variables (for example, news on the macroeconomic outlook or changes in expectations). In their study endogeneity is captured in the following two equations:

$$\Delta i_t = \beta \Delta s_t + z_t + \varepsilon_t \quad (3.1)$$

$$\Delta s_t = \alpha \Delta i_t + z_t + \eta_t \quad (3.2)$$

where

Δi_t measures the change in the short-term interest rate, and

Δs_t measures the change in an asset price.

Equation 3.1 represents a monetary policy reaction function that captures the expected response of policy to a set of variables z_t and to the asset price. Equation 3.2 is the asset price equation, which allows the asset price to be affected by the interest rate and also by the other variables (z_t). The parameter of interest is α , which measures the impact of a

change in the short-term interest rate Δi_t on the asset price Δs_t . The variable ε_t is the monetary policy shock, and η_t is a shock to the asset price. Those disturbances are assumed to have no serial correlation and to be uncorrelated with each other and with the common shock (z_t) (Rigobon and Sack, 2002:3).

The two equations cannot be estimated using ordinary least squares (OLS) due to simultaneity bias and missing variables. Rigobon and Sack (2002:4) addressed these problems by focusing on periods immediately surrounding changes in the policy instrument; what has been often referred to as the event study⁵. This approach relied on regressing changes in the market interest rates to changes in the Federal Reserve funds rate on a sample of days when the Federal Reserve fund rate changed. The event (a policy day) is an increase in the variance of the policy shock, which changes the co-variance structure of the observed variables. If the shift in the variance of the policy shocks was infinitely large, then the heteroskedasticity estimates will in fact converge to the standard event-study estimates. However, according to Rigobon and Sack (2002:8), the heteroskedasticity-based estimator's $\hat{\alpha}$ does not require such a strong assumption to be consistent.

The results of the heteroskedasticity and the event study approach for all the stock indexes are as follows: the indexes considered had a significant negative reaction to monetary policy shocks. A 25 basis points rise in the short term interest rates resulted in 1.9% decline in the S&P index. A similar response was found for the broader market, the Wilshire 5000. The NASDAQ index showed a considerably larger reaction, while the Dow Jones had the smallest reaction. Treasury yields also responded strongly to monetary policy, and the estimates were significant across all maturities. In response to a 25 basis point increase in the three-month rate, the treasury yield curve shifted up by 18 to 22 basis points for maturities out to five years and by a smaller amount for maturities beyond that. The responses of the futures rates under the heteroskedasticity-based estimator were sizable and strongly significant across all the horizons considered. Near-term euro/dollar futures rates increased by more than 25 basis points, but the response

⁵ See Cook and Haan (1989) for a detailed review of the event study approach.

began to diminish steadily at horizons beyond one year, falling to 14 basis points for a contract expiring in five years (Rigobon and Sack, 2002:23).

With regard to the volatility relationships, very little empirical research is available. As noted in section 3.0, the few available studies have exclusively focused on advanced markets, ignoring trends in emerging markets. Given the lack of empirical evidence for emerging markets, the only study that is available by Rigobon and Sack (2003a) will be reviewed in this section.

Rigobon and Sack (2003a) examined the volatility interactions between the three month treasury bill interest rate, the 10 years interest rate (which is measured by the slope of the yield curve) and the return on the S&P 500 in the US. Since the focus of their study was on measuring the high frequency dynamics between the three variables, daily data was used. Their methodology is very useful and can be extended to include other financial variables like the exchange rate. The dynamics of the three variables were described by the following structural GARCH model:

$$Ax_t = \Psi + \Phi(L)x_t + \Phi(L)z_t + \eta_t \quad (3.3)$$

where $x_t \equiv \{i_t, s_t, y_t\}$

In the model, the matrix A captures the contemporaneous relationship among the three variables, which is of primary interest in the current study. Ψ is a vector of constants, and $\Phi(L)$ is a lag function that controls for the lags of the endogenous variables. The specification also allows the other endogenous variables, denoted by z_t , to affect these financial variables; these could include macroeconomic variables or commodity prices. The vector $\eta_t \equiv \{\eta_i, \eta_s, \eta_y\}$ represents the “structural shocks” or innovations to the latent factors that drive asset price movements (Rigobon and Sack, 2003a:4). It is assumed that the conditional expectation of asset prices is equal to zero. Following the theory of GARCH, the authors assumed that the variances of the structural shocks exhibited

conditional heteroskedasticity in the same manner that the GARCH model assumes for the reduced shocks (Rigobon and Sack, 2003:5).

The conditional variances of the structural shocks are then given by the vector $h_t \equiv \{h_{it}, h_{st}, h_{yt}\}$. The conditional variances are assumed to evolve based on their lagged values, the magnitude of the most recent shocks, and the vector of three constants Ψh . As noted earlier, the problem of endogeneity will also complicate the analysis. However, identification can be achieved when there is conditional heteroskedasticity. According to Rigobon and Sack (2003a:6), the intuition for this is straightforward: as the conditional variances of the structural shocks shift over time, the conditional co-variances between the variables must shift in a manner that depends on the contemporaneous responsiveness to one another. They illustrate this by considering the case when the short term interest rate has a negative impact on equity prices and equity prices have a positive impact on interest rates. In this case, periods in which shocks to stock prices are more volatile cause a positive correlation, while periods where shocks to interest rates are more volatile cause a negative correlation. This identification methodology is similar to the one used in a related study (see Rigobon and Sack, 2003b) where they investigated the effect of short term interest rates on stock prices. In that study, they defined the discrete regimes for the variance of the stock market and interest rates and relied on the shift in the co-variance matrix of shocks across regimes to recover the response coefficients. In contrast, Rigobon and Sack (2003a:6) allowed the variance of shocks to evolve in a continuous manner, which provided a continuum of regimes for identifying the contemporaneous responses. This approach allowed them to simultaneously estimate the response of all financial assets to one another.

Rigobon and Sack (2003a) found that all the contemporaneous response coefficients were significant, indicating that there were strong links across different financial instruments (Rigobon and Sack, 2003a:11). The parameters also had the expected signs as predicted by macroeconomic theory. The equation of the interest rates was interpreted as a monetary policy reaction function. The results showed that movements in equity prices generate movements in interest rates in the same direction. A 1% increase in the S&P 500

index had a direct effect of 0.51 basis points on the short rate. Results also indicated that the short rate responded to the slope of the yield curve. This was interpreted as an increase in the slope of yield curve indicating expectations of higher future inflation, thus warranting a response of the short-term rate. The slope of the yield curve reacted negatively to the short-term rate, where a 1% increase in the short rate resulted in a 77 basis points decline in the yield curve. The yield curve also responded positively to changes in equity prices, perhaps because such increases boost aggregate demand and raise inflationary pressures; a 1% increase in equity prices had a direct impact of 0.32 basis points on the yield curve. A 1% shift in the yield curve also pushed equity prices down by 3.6%, while a 1% point steepening had a negative impact of 4.3%. The equity market shock can arise either from news that affects investors' expectations of future dividends or a shift in investors' risk preferences. This is consistent with expectations based on the discounted models of share valuation (Rigobon and Sack, 2003a:12).

Impulse response analysis was carried out to determine the response of the conditional variances of each variable to a one standard deviation of shock to each of the three structural form innovations. The conditional variance of each of the variables responds considerably to its own shock. But the variances also responded to other shocks. The variance of the yield curve responded the most to the innovation to the short rate. In all cases, the variances demonstrated some persistence. Shock to interest rate tends to make the co-variance more negative over the subsequent weeks. According to Rigobon and Sack (2003a:14), this arises because the shocks tended to be followed by additional interest rate shocks. Shocks to the yield curve also induced a period of negative co-variance. In contrast, co-variance became more positive following a stock market shock, as the system was likely to be driven by additional stock market shocks, which generate movement in interest rates in the same direction. The co-variances between the other two pairs of the variables also exhibited rich patterns that differed across various shocks. An important driver of the covariance between the short rate and the yield curve slope appeared to be shocks to the short term interest rate, reflecting the large impact of those shocks on the yield curve to (Rigobon and Sack, 2003a:14-15).

According to Rigobon and Sack (2003:15), the most important implication of this model is that understanding the source of shock driving asset price movement is crucial. Moreover, they argue that analysing the behaviour of a single asset is misleading, since the same movement in the price of an asset could be driven by innovations to its own shock or by the endogenous response to a shock of another asset price. By recovering the interactions between the variables in the above equations, the model allowed the researchers to determine the source of the shock by looking at the contemporaneous movements in other asset prices (Rigobon and Sack, 2003:15).

A closely related study is by Chiarella *et al.*, (2002), which examined the interaction between asset prices and output in the United States for the period January 1960 to October 1993. The study employed monthly data on industrial production (PR), monthly treasury bills (TB), and stock prices (ST). While most researchers usually employ the stochastic optimal growth model of RBC (Real Business Cycle), Chiarella *et al.*, (2002:1) applied a macro dynamic model which is a generalisation of the 1981 Blanchard model.

Their results indicated that all the estimated parameters have the right sign. The estimated impulse responses were as follows: a positive shock to PR had only short-run effects on PR, which became significantly negative after two periods and then died off; the short-run reaction of TB was significantly positive but vanished after three periods; the simultaneous response to ST was negative, while lagged responses were insignificant. A shock to TB affected TB itself positively for one lag, but the effect disappeared beyond the second period. Results showed that the initial response of ST to the interest rate shock was negative; this response was marginally significant, but then practically disappeared after lag one. There are responses of PR to the interest rate shock but they were not significant. Finally, a positive shock to the stock returns (ST) was followed by a significantly negative return in the following period which was about a quarter of the size of the shock, whereas higher-order responses were practically zero. The responses of DPR and TB to ST were also not significant. They concluded that the positive interest rate shock moves the stock price down but also output falls (Chiarella *et al.*, 2002:30).

In summary, the results indicated that stock prices and interest rates are related. The results of Rigobon and Sack (2002:13-15) showed that monetary policy shocks have a significant impact on stock prices. In addition, their results also showed that a shock to stock prices moves interest rates in the same direction, while interest rates shocks led to changes in the opposite direction. Taken together, the results of these studies indicate that there exists a significant relationship between stock prices and interest rates. With respect to the interactions of volatility Rigobon and Sack (2003a:15) found evidence of strong correlations between market volatilities.

3.2 EXCHANGE RATES AND STOCK PRICES

In the literature, exchange rates have always been the focus of empirical and theoretical research, while stock markets have received little attention. However, the recent strong performance of international stock markets and the growing importance of such markets in the international financial system have stimulated empirical research in this area. In particular, recent financial crises and instability have highlighted issues about the interaction between these markets and the implications for financial instability. While a few authors have examined the relationship between the markets, none of these studies examines the volatility interaction between the markets (see, for example, Phylaktis and Ravazzolo (2000)). The study examined the relationship between stock prices and exchange rates and found evidence of a significant positive relationship.

Although the results of most studies provide evidence of a significant relationship, on the issue of causation these studies have mixed results. Some studies argue that changes in stock prices lead changes in exchange rates (see Phylaktis and Ravazzolo 2000) and others are of the view that exchange rate shocks lead changes in stock prices (see Huzaimi and Liew 2004). Phylaktis and Ravazzolo (2000:14) found evidence of unidirectional causality from stock prices to exchange rates. On the other hand, Huzaimi and Liew (2004:16) found evidence of bi-directional causality between exchange rates

and stock prices in Malaysia. However, in Thailand they found evidence of unidirectional causality from exchange rates to stock prices.

The major limitation of these studies is that they focus mainly on the trends in the two markets, while paying little or no attention to the volatility interactions between the markets. Such interactions are important because they can provide useful clues about the transmission of shocks across the markets giving rise to contagion. In view of the fact that limited studies are available that examine the interaction between stock prices and exchange rates, this section reviews related studies on the relationship between the two variables. In addition, the few available studies that examine interactions between market volatilities will also be reviewed.

Phylaktis and Ravazzolo (2000) examine the long run relationship between the stock market and the foreign exchange market in the Pacific basin. The real exchange rate was used, which is defined as the domestic price level relative to the foreign price level. Six countries were selected, and these included Hong Kong, Indonesia, Malaysia, Singapore, Thailand and the Philippines. The sample period was January 1980 to December 1998. In order to study the impact of liberalisation on the short run and long run dynamics of the variables, the sample was divided into two periods. Period 1980 to 1990 is defined as the pre-liberalisation period, while 1990 to 1998 is the post liberalisation period. The data consisted of monthly stock prices indices, real bilateral exchange rates and the consumer price index. The stock market indices used were the Hang Seng Price Index (Hong Kong), Jakarta SE Composite Price Index (Indonesia), the Kuala Lumpur Composite Index (Malaysia), the Philippines SE Composite Price Index, and the Singapore Straits Times Price Index, the Bangkok SET Price Index (Thailand) and the Standard & Poor's Composition Index (USA). The relationship between stock prices and the real exchange rate was represented by the following equation:

$$P_t^{PBC} = \alpha_0 + \alpha_1 S_t^{PBC} + v_t \quad (3.4)$$

where

P_t^{PBC} is the index of stock prices

S_t^{PBC} is the real exchange rate.

In addition to an examination of the short run and long run dynamics, the study also examined the channel that links the stock market to the foreign exchange market. Two of the channels that link stock prices and exchange rates were tested, namely the “stock” and the “flow” approach. According to the flow approach, a fall in the real exchange rate⁶ affects the competitiveness of domestic goods relative to foreign goods. This reduces the price of local goods (exports), leading to an increase in the demand for domestic goods and aggregate demand. Given the positive correlation between stock prices and company profits, higher aggregate demand will stimulate the stock market, thereby increasing stock prices. In equation (3.4) above $\alpha_1 < 0$; thus a fall in the real exchange rate increases stock prices. According to the stock approach, exchange rates move to balance the demand and supply of financial assets. Any change in the demand and supply of assets affects exchange rates. A higher stock market increases wealth and the demand for money and as a result, interest rate will rise. Higher interest rates attract capital inflows, resulting in an appreciation of the currency and a rise in the real exchange rate. Therefore in the stock approach $\alpha_1 > 0$ since an increase in stock prices increases the real exchange rate (Phylaktis and Ravazzolo, 2000:6).

The Johansen cointegration methodology was employed to test the long run relationship between stock prices and real exchange rates. A bivariate VAR equation system was estimated for each Pacific basin country. The results of the bivariate cointegration failed to reject the hypothesis of zero cointegration vectors for all the countries except Hong Kong in the second sub-period. Granger causality tests were employed to test the causality between stock prices and the real exchange rates for Hong Kong. Causality

⁶ The real exchange rate is defined as the domestic price divided by the foreign prices multiplied by the nominal exchange rate (Phylaktis and Ravazzolo, 2000:6).

from real exchange rate to stock prices was strongly rejected; however, causality from stock prices to real exchange rate could not be rejected (Phylaktis and Ravazzolo, 2000:6).

According to the authors, a failure to reject the hypothesis of zero cointegration could be caused by the omission of a third variable, which provides a link between the variables. In this case the missing link is the US stock market as a proxy for international stock markets. The performance of the US stock market can be an indicator for strong performance of the US economy. A stronger US economy will increase US imports from the domestic countries and increase their exports, thus leading to an appreciation of their currencies. On the other hand, a greater level of integration of Pacific basin countries into the world economy will also increase their stock markets, given an increase in the US stock market (Phylaktis and Ravazzolo, 2000:7).

To take into account the influence of the US stock market, the following trivariate system was estimated:

$$P_t^{PBC} = \alpha_0 + \alpha_1 S_t^{PBC} + \alpha_2 P_t^{US} + v_t \quad (3.5)$$

where

P_t^{PBC} is the price index in the pacific basic countries

S_t^{PBC} is the real exchange rate

P_t^{US} is the US stock index.

In this model, the coefficients α_1 and α_2 are expected to be positive under both the “stock” and “flow” approaches⁷. The possibility of the omission of a variable was incorporated by including the US stock market as a proxy for international stock markets. The results of trivariate system indicated a failure to reject the hypothesis of zero cointegration for all countries except Hong Kong in the first sub period. Conversely, in the second sub period, the results showed that the hypothesis of at least one cointegrating vector could not be rejected. In addition, results found evidence of a positive relationship between stock prices and real exchange rates for all countries for the period 1990 to 1998. The results also showed that US stock market was driving the Pacific basin markets, confirming the links between the economies and the US on the one hand and the US price leadership (Phylaktis and Ravazzolo, 2000:16). The results further showed the channel through which the foreign exchange and the local stock markets were linked. In Indonesia and Singapore, the markets were connected through the “flow” channel.

A recent study on emerging market stock markets by Huzaimi and Liew (2004) examined the relationship between stock prices and exchange rates in the context of Malaysia and Thailand for the period 2 July 1997 to 31 August 1998. The study tested for causal links between stock prices and exchange rates in order to identify the leading market; which is the market that is the primary source of shocks. In addition, the study sought to examine the links between the Malaysian and Thai stock markets.

The sample used consisted of US dollar based daily spot exchange rates of the Malaysia ringgit (MYR/USD) and the Thai baht (THB/USD) and daily stock prices of Kuala Lumpur Stock Exchange Composite Index (KLCI) and Stock Exchange of Thailand Index (SETI). Daily data was used rather than a lower frequency data set because it contained more information as changes in macroeconomic variables and daily news; global markets all affect financial markets instantaneously. Market reaction and transactions were thus captured more fully by daily data than weekly data or monthly data; all variables were in their logarithmic forms.

⁷ Higher US stock market will increase Pacific basin stock markets, due to integration of international stock markets. A stronger US economy will also increase exports from the Pacific basin countries leading to an appreciation of the real exchange rate.

Granger causality tests were employed to study the causal links between exchange rates and stock prices. In addition to the standard Granger causality tests, both the Sims causality and the Geweke-Meese-Dent test were used in this study. This was done in order to explore all the possible causality relationships between the variables.

Results showed that the null hypothesis of exchange rates do not cause stock prices was rejected in Malaysia at 5% significance level by the Granger causality test but not the other two tests. Since the other tests were complementary, the authors concluded that there was a causality relationship if one of the tests rejects the null of no causality at 10% or less. They therefore concluded that exchange rates cause stock prices in Malaysia. The hypothesis of stock prices do not cause exchange rates was also rejected in Malaysia by the Sim (5%) and Geweke-Meese-Dent (10%) tests (Huzaimi and Liew, 2004:14). This implies that causality running from stock price to exchange rate is also working in the Malaysian financial markets. Thus, the results indicated that there exists bi-directional causality between exchange rate and stock prices in Malaysia.

Applying similar interpretation to Thailand, a unidirectional causality from exchange rate to stock price was found at 10% level. There was no reverse causality relationship at 10% level. An examination of the causal links between the stock markets across the countries and their exchange rates indicated that there was a bi-directional causality between the stock prices of Malaysia and Thailand (significant at least 5% level). This suggested a close interrelation between the stock markets of the two neighbouring countries. In contrast, tests failed to detect any causal relationship between the baht and ringgit, indicating that the foreign exchange markets in these two countries are independent from each other. There is also no direct relationship among foreign exchange markets and stock exchange markets across these countries (Huzaimi and Liew, 2004:16).

Empirical studies support the idea that stock markets and exchange rates are related; Phylaktis and Ravazzolo (2000:6, 16) found a significant relationship. With regard to the issue of causation, there are mixed results. Huzaimi and Liew (2004:14-16) found

evidence of bi-directional causality in the case of Malaysia and unidirectional causality running from exchange rates to stock prices in Thailand. In addition, empirical studies show that exchange rates are an important channel for the international transmission of stock market shocks. This has important implications for financial instability. Explicitly, the exchange rate channel can be a source of instability through the international transmission of shocks.

A closely related study is the work of Rigobon and Pavlola (2003), where the authors examine the relationship between international stock markets and exchange rates of the US, United Kingdom (UK) and Germany. Specifically, the study aimed to examine the correlations between international stock markets and to test the hypothesis that exchange rates provide a channel for the international transmission of shocks. Understanding and identifying interrelations between these markets would shed light on some widely debated spillover, such as, for example, international financial contagion (Rigobon and Pavlola, 2003:1). Data sample included the three month zero-coupon government bonds, stock markets indexes and the dollar-pound and dollar-mark exchange rates.

The authors employed an identification strategy similar to that used by Rigobon and Sack (2003a:5). The parameters were estimated using generalized method of moments (GMM). A plot of the evolution of the exchange rate and the stock and bond prices suggested that bond prices do not bear much relation to exchange rates. Results of the regression analysis confirmed their observations⁸. On the other hand, the co-movement between the stock index and the exchange rates was very high. Results of correlation exercises were also found to be highly statistically significant. The coefficients for the stock markets were statistically significant, while those of the bond market were not. For the US and Germany, the estimates were statistically significant at 5% level. In sum, the results supported the hypothesis of a co-movement between stock markets and exchange rates even though some rejections of their implications were found mostly regarding the bond prices dynamics.

⁸ Thus, the authors argue that the results may be interpreted as a failure of uncovered interest rate parity

With regard to the volatility relationship, Yang and Doong (2004) investigated the interactions of price and volatility spillovers between the stock market and the foreign exchange market for the G-7 countries. They examined the extent to which the markets are integrated by testing both price and volatility spillover effects. In addition, they also tested for the presence of asymmetric effects in the conditional variances.

The sample period was from May 1979 to January 1999. The data set consisted of weekly closing exchange rates and stock indices for the G-7 countries. The stock indices for the G-7 countries included were Toronto 300 Composite (Canada), Paris CAC 40 (France), Frankfurt DAX (Germany), Milan Stock Index (Italy), Nikkei 225 (Japan), FT-100 (UK), and S&P 500 (US). Weekly data were used instead of daily data because it did not contain too much noise, but was also better than monthly data which would not enable them to study the dynamics. Yang and Doong (2004:141) argue that this framework is useful because not only does it enable one to understand the nature of the volatility transmission mechanism, but it also allows one to understand how the size and the sign of the innovations affect volatility spillovers-asymmetric effect (Yang and Doong (2004:141)).

Since the data contained ARCH effects, a multivariate version of Nelson's (1991) EGARCH model was estimated. The EGARCH model was preferred because of the log form of the conditional variance, thereby guaranteeing that the variance will be positive. They further argued that other GARCH models such as the GJR model need to have parameter restrictions to ensure the non-negativity of the conditional variances (Yang and Doong, 2004:144).

Their results indicated that there existed significant price spillovers from the foreign exchange to the stock market for Canada and Japan. They argued that currency depreciation (or appreciation) often dragged down (up) stock prices for Canada and Japan. In the long run for an economy with a significant import (export) sector, the unfavourable effects of currency depreciation (or appreciation) on imports (exports)

might induce a bearish⁹ stock market. However, in the short run, currency depreciation might have a negative effect on the stock market because the domestic counterpart of currency depreciation is inflation, which may exert a dampening effect on the stock market. In addition, the inflationary effects of a declining domestic currency may encourage international investors to decrease their portfolio of domestic assets, thereby depressing the stock market in the long run (Yang and Doong, 2004: 147).

The results also found significant price spillovers from the stock market to the foreign exchange market for Canada, France, Germany, Italy, and the UK. It was revealed that an increase (or decrease) in stock price often caused currency depreciation (or appreciation) for the next week or two for France, Germany, Italy, and the UK. The short-run negative effect of increases in stock prices on domestic currency value can be explained by the stock market providing a barometer for the health of an economy. A booming stock market reflects economic expansion, and this tends to fuel inflation expectations. An increase in inflation expectation exerts downward pressure on the value of the domestic currency in the short run. In the long run, however, the positive effect of an increase in stock prices on exchange rates is consistent with the asset view of exchange rates (see for example Yang and Doong, 2004:147). While in general the results found that there were significant price spillovers from the stock market to the foreign exchange market, there were no converse spillovers from the foreign exchange market to the stock market. This implies that changes in stock prices signal important information about economic fundamentals to the foreign exchange market, but exchange rate movements do not convey much information about future stock price movements.

Results of EGARCH indicated that there existed volatility spillovers from the stock market to foreign exchange markets for France, Italy, Japan, and the US. However, no volatility spillovers were found from the foreign exchange to the stock markets at all. In terms of asymmetric spillover effects, negative innovations in the stock market had greater impacts on the conditional volatility of exchange rates than positive innovations

⁹ Bearish - derived from the word bear market, which described a sellers' market where selling pressure causes a sharp decline in stock prices (Wikipedia, 2006:1)



for France, Italy, Japan, and the US. However, the effects did not apply to innovations in exchange rates on the stock markets. Empirical evidence demonstrated that volatility of stock prices have (asymmetric) impacts on price movements of foreign exchange rates. Both price and volatility information from the stock market have pricing impacts on the behaviour of exchange rates.

3.3 EXCHANGE RATES AND INTEREST RATES

The relationship between exchange rates and interest rate volatility is a source of fierce debate. Reinhart and Reinhart (2001) argue that exchange rate variability is stabilising since it releases pressure on the rest of the economy and promotes stability in such macroeconomic aggregates like interest rates, implying that there is a volatility trade-off between exchange rates and interest rates. According to this view, a fluctuating exchange rate will encourage a more stable monetary policy since authorities will not attempt to stabilise exchange rates by adjusting interest rates (Reinhart and Reinhart, 2001)¹⁰. On the contrary, exchange rates respond to monetary policy and authorities can adjust the official rate to smooth exchange rates. While this is often the case within developed countries, the same does not always hold true for developing countries. It is often the case that in developing countries there is a disconnect between exchange rates and interest rates. This is true where developing countries are faced with credibility issues. As noted earlier, when countries have credibility issues, exchange rate and interest rates volatility can move together (Belke *et al.*, 2003:4). While literature on the interaction between exchange rate and interest rate volatility is virtually non-existent, one study is available. This study is reviewed below.

Belke *et al.*, (2003) examined the links between exchange rate and interest rate volatility in the MERCOSUR countries (i.e. Argentina Brazil, Uruguay and Paraguay) for the period 1970 to 2000. Specifically, the authors tested the hypothesis of a volatility trade-off in the respective countries. Since developments in international financial markets and

¹⁰ See Belke, *et al.*, (2003: 1-3) for a more detailed survey of literature

developed countries have a significant effect on emerging markets, they examined G3 volatility and volatility in developing countries like Argentina, Brazil and Uruguay. A very simple measure of volatility was used: for each year of the total sample, they calculated a standard deviation on the basis of twelve monthly observations of the first difference of the respective exchange rate and interest rate measure. Monthly exchange rates and interest rates volatilities were used, instead of daily (or other higher frequency data) due to availability of monthly rates.

To take into account the close ties of the MECOSUR countries to the European Union (EU) and the US due to unique trading patterns, the nominal and the real euro/dollar exchange rates were used. To measure volatility of the MECOSUR currencies themselves, both the nominal and real bilateral U.S dollar and euro exchange rates were used. In addition, the real effective exchange rates of the MECOSUR currencies were also used. Finally, the intra MECOSUR nominal and real exchange rates as well as the effective exchange rates were also used.

In the case of Argentina, Paraguay and Uruguay, deposit rates were used as a measure of interest rates. In the case of Brazil, the money market rates were used. For the euro zone, German money market rates were used while the US interest rate was approximated by the treasury bill rate. When calculating the relevant volatilities for the euro-dollar relationship, the interest rate differential (calculated as the difference between US and euro interest rates) was used instead of the interest rate levels because it was not obvious whether the US interest rates is exogenous to the euro interest rates, as might be presumed of the US interest rate for Argentina.

The authors conducted simple tests of the significance and of the sign of the correlation between the relevant volatility measures. The expectation was a negative sign if there was a volatility trade-off and a positive sign where volatilities moved together. Correlation between the nominal dollar/euro volatility and volatilities of interest rates differential was about 0.13; between the real dollar/euro and interest rate variability, correlation coefficient was about 0.19. In addition, correlation between volatilities of the dollar and

the euro real effective exchange rate and the real interest rate differential was found to be -0.03 and -0.18; but not very significant. Correlation between exchange rate and interest rates variability for MERCOSUR countries was found to be very strong. In certain cases (Argentina) exchange rate and interest rate volatility were found to be the same. In addition, the correlation between dollar-euro volatility and interest rate volatility for MERCOSUR countries was not very strong; about 0.29 and -0.16 (Belke, *et al.*, 2003:15-23).

The results from the correlation exercises show that for countries subject to speculative attacks and/or bouts of hyperinflation (for example Argentina where volatilities move one to one) exchange rate and interest rate volatility move together. The contrary is true for major floating exchange rates like the dollar and the euro. Exchange rate volatility was found to be unrelated to interest rate volatility (Belke *et al.*, 2003: 17).

3.4 CONCLUSION

The chapter discussed the empirical literature on the links between the financial markets. It specifically focused on those studies that examined interaction of market volatilities. Empirical evidence supports the hypothesis of a negative relationship between stock prices and interest rates. A strong contemporaneous correlation between the variables was also found; however, the direction of the response depends on the source of shock. Shocks from stock prices lead to a positive response in interest rates, while shocks from interest rates lead to a negative response in stock prices.

Empirical studies support the hypothesis of co-movement between stock prices and exchange rates, implying a positive relationship between the two. Studies also found significant volatility spillovers from the foreign exchange market to the stock market. In addition, the foreign exchange market was found to be an important channel for the international transmission of shocks. With regard to exchange rates and interest rate

variability, empirical evidence found that for countries subject to hyperinflation and speculative attacks, the two move together, implying a positive volatility relationship.

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

CHAPTER FOUR

OVERVIEW OF TRENDS AND BEHAVIOUR OF THE SOUTH AFRICAN MARKETS

4.0 INTRODUCTION

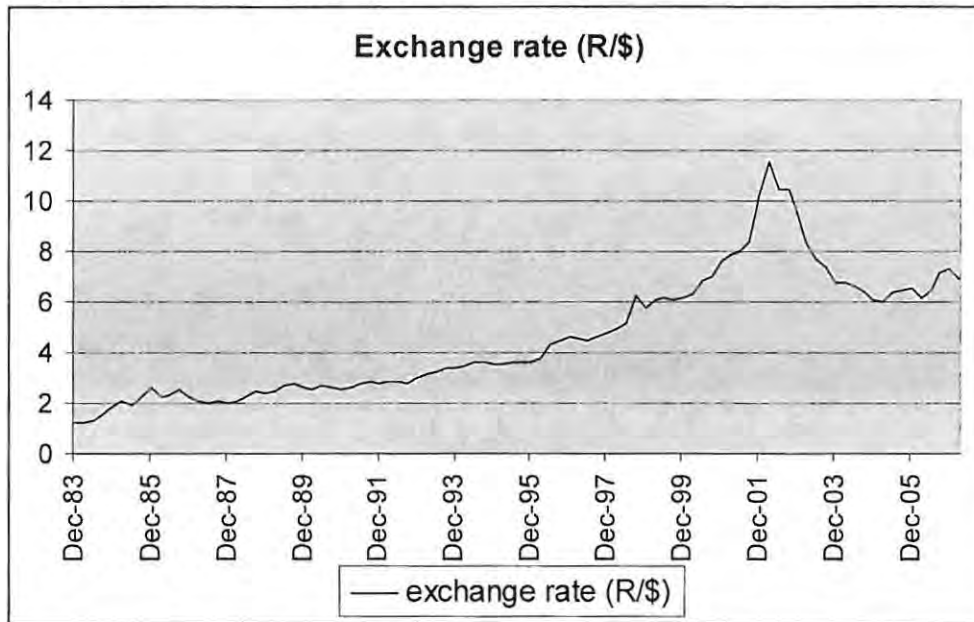
This chapter provides an overview of the trend and behaviour of the South African markets. The major focus of the chapter is on examining volatility trends in each of the markets. The discussion focuses on periods of heightened market volatility which includes 1986 to 1990, the period of exchange controls and market restrictions and the period 1996 to 2006 which covers the period of market liberalisation. A key feature of the earlier period is the political instability that was driving market movements. This is in contrast to the latter period where volatility is driven by instability in the international financial markets.

The chapter is organised as follows: section 4.1 discusses the behaviour of the exchange rate of the rand; section 4.2 discusses the behaviour of stock prices; section 4.3 discusses the behaviour of interest rates; section 4.4 provides a summary of the discussion and section 4.5 concludes.

4.1 THE LONG TERM BEHAVIOUR OF THE EXCHANGE RATE

This section discusses the behaviour of the exchange rate of the rand. Figure 4.1 plots the rand/dollar exchange rate over time from the period 1983 to 2005. Over this period the performance of the rand against the US dollar (USD) was characterised by a weakening trend. The weakening rand could be a reflection of the inflation differential between South Africa and the US and the relative unattractiveness of South African financial assets relative to dollar denominated assets (Commission of Inquiry, 2002:2).

Figure 4.1: Long term performance of the rand against the dollar in the past 28 years



Source: Inet

Prior to 1990, the behaviour of the exchange rate was influenced by exchange controls and strict rules regulating international investments. These restrictions were mainly aimed at limiting fluctuations in the exchange rate and discouraging capital outflows. Despite this, exchange rates were highly unstable. During this period, both the financial and commercial rand plunged to historical lows, losing over 30% of its trade weighted value (Commission of Inquiry, 2002:3). Generally, exchange controls failed to stabilise the exchange rate which continued to depreciate against the dollar.

The liberalisation of the South African market exposed the rand to international investors, making the rand vulnerable to speculative attacks and changes in investor confidence. In the period immediately after floating, the rand was stable at R3.40 to the USD. The uncertainty with regards to economic policies of the new government increased market risk increasing aversion to South African assets. This led to a massive sell-off of rand assets that caused the rand to depreciate to R4.20 to the dollar. In the three years following the floating of the currency, the rand was stable, trading within the range R3.20- R4.50 to the USD (Commission of Inquiry, 2002:4).

Between 1996 and 2001, the rand performed very poorly against the dollar. This was not only the sharpest decline, but also the longest sustained depreciation of the rand. In August 1997 East Asia experienced a series of asset price declines and currency declines that escalated into a financial crisis. The crisis triggered capital outflows from emerging markets, including South Africa. As of the start of the crisis in October 1997 to the end of the crisis in December 1999, the rand depreciated by more than 20% against the USD (Commission of Inquiry, 2002:4). While this decline was quite sharp, the rand's decline was mild as compared to that of the Asian countries that experienced a crash in their exchange rates. In fact, at the height of the crisis (June to October 1997) the rand depreciated by only 6% against the dollar and by 5.9% against a basket of currencies (SARB, 1997:36).

While financial markets recovered from the Asian crisis, on September 11, 2001 the World Trade Center in the US was the target of terrorist attacks. Rising tensions following the attacks led to a fall in investor confidence. This fuelled a second attack on emerging market currencies. The rand depreciated to unprecedented levels; at the beginning of 2001, the rand was trading at R7.60, falling to R8.0 in the second quarter and a shocking R13.43 by the end of the year (Commission of Inquiry, 2002: 9). While the attacks on the US were the major causes of the rand's volatility, a number of internal shocks also weighed heavily on the exchange rate of the rand. These included the introduction of capital gains tax and the land crisis in Zimbabwe (SARB, 2001:30).

Following the prolonged decline, the rand recovered strongly thereafter and continued to strengthen against the dollar in 2003 and 2004. This was a period of high exchange rate volatility, where the rand traded at levels last seen in 1996. Volatility was further enhanced by the increasing capital inflows and the growing interest of foreign investors in South African equities (SARB, 2004:60). Volatility however, remained well below the highs reported in the third quarter of 2002 and the first quarter of 2003, where the rand traded in the range R 10.50-R8.00 to the dollar.

Thus far, the focus has been on the long term movement of exchange rates. The general movement of the rand is characterised by a weakening trend. However, this is hardly a smooth trend; exchange rates exhibited high volatility. There were periods where volatility increased significantly. These include: (1) during the debt standstill of 1985; (2) the period following the abolition of the dual exchange rate system 1996; (3) the 1998 Asian crisis; (4) and the September 11, 2001 terror attacks on the US (Commission of inquiry, 2002:2-4).

The table below shows a range of dates where the rand depreciated by more than 10% against the USD.

Table 4.1: Periods of exchange rate depreciation

Date	ZAR/USD Rate	Percentage Change
Dec 87 - May 89	1.93 - 2.79	44%
Jan 96 - Oct 96	3.65 - 4.70	29%
Jan 98 - Jul 98	4.80 - 6.40	33%
Nov 99 - Dec 01	6.10 - 12.00	97%
Dec 04 - Oct 05	5.67 - 6.70	18%

Source: Dyer and Ince (2006:17)

While the major trend was that of a weakening rand, there were periods of sustained appreciation of the exchange rate. Table 4.2 below shows the appreciation of the exchange rate over a range of dates, as well as the percentage change.

Table 4.2: Periods of exchange rate appreciation

Date	ZAR/USD rate	Percentage Change
Jul 98 - Nov 98	6.40 - 5.69	11%
Dec 01 - Dec 02	12.00 - 5.67	53%
Oct 05 - Apr 06	6.70 - 6.05	10%

Source: Dyer and Ince (2006:17)

As far as the exchange rate is concerned, volatility has always been a key feature of the market. In terms of the drivers of volatility, prior to 1995 political instability was the major driver, while post 1995, external shocks were the major drivers of volatility. In addition, volatility has increased since market liberalisation. It appears as if the exposure of the South African market to international financial markets has actually led to an increase in volatility over time. This has made the rand highly susceptible to exogenous shocks such as the Asian crisis, or any emerging market crisis.

4.2 LONG TERM BEHAVIOUR OF STOCK PRICES

This section briefly discusses the long term behaviour of stock prices. The discussion will particularly focus on the period 1996 to 2006. This period covers the bear market¹¹ in 1998 and the recent bull¹² market. The South African stock market is mainly resourced-based. Therefore, movements in resource prices (especially gold and platinum) have a significant influence on the resource index on the one hand, and the all share index on the other hand (Beelders, 2002:4-5). Therefore in order to trace the behaviour of this variable it is important to consider the impact of the resources index on the all share index.

¹¹ A sellers' market, describes a market where sellers are more than buyers, leading to downward pressure on stock prices. (Wikipedia, 2006:1)

¹² A buyers' market, describes a market where there are more buyers than sellers, putting upward pressure on prices.

Figure 4.2: Long term movement of the all share index: 1973 – 2007



Source: Inet

Figure 4.2 plots the long term movement of the all share index. As can be seen from the graph, South African equities have been on an upward trend since end of 1987. Exchange controls and rules restricting foreign stock brokers from trading on the JSE discouraged foreign investments in South African equities (Faure, 2005:160). As a result there was limited activity on the JSE. During the period 1975-1987 the all share index was flat and averaged 700 index points. Stock prices increased somewhat at the end of the sanctions period in 1989; however, the all share index remained below 1000 points. The all share index rose above 1000 points for the first time in 1989. Between 1991 and 1996 the all share index rose to record levels, increasing from 1000 points in 1991 to 6000 points by end of 1996.

The liberalisation of the South African financial markets increased activity in the stock market. Recovery in the South African economy and improvement in business and consumer confidence generally supported equity prices (SARB, 1997:1). Although the termination of exchange controls in 1996 was generally positive for stock prices, this also increased volatility in the stock market.

The long term behaviour of South African equities is characterised by an upward trend. However, stock prices exhibited high volatility. In addition, there were periods of sustained declines in stock prices. The emerging market crisis that began in October 1997 is a case in point. The classification of South Africa as an emerging market resulted in an indiscriminate selling of South Africa equities. By the beginning of October 1997, the all share index declined by 2.8% before the plunge in global equity markets caused the all share index to decline by over 3.4%. According to the South African Reserve Bank (1997:53), the decline in share prices was relatively moderate as compared to the crash in 1987. While the all share index declined by 21% from the start of September to the end of October, the monthly average decline in gold stocks during the crash in 1987 was 44% (SARB, 1997:41).

From 1997, foreign investors became active participants in the equity market, increasing their purchases and sales to 31.7% of total trades. In 1998, this declined to 29% which although was slightly less than the comparable ratio (31%) in 1997, it was still significant. At the same time, non-residents also increased their holdings of South African equities by R38 billion in the first ten months of 1998. According to the SARB (1998:28) this could have been a sign that general risk aversion of global investors to emerging market assets did not necessarily extend to South African equities. In fact, between December 1997 and May 1998, the monthly average of stock prices increased by 32.3% to reach an all time high before a sharp decline of 38.7% by September 1998.

In September 1998, the all share index reached the lowest level in 4 years, which was approximately equal to that of 1994. Share prices began to recover in October 1998. However, despite the increase and a strengthening in the rand, the all share index was down 26% in dollar terms (SARB, 1998:28).

By the end of 1999, the world economy led by the US economy showed signs of a recovery. This recovery gained momentum as conditions in East Asia stabilised. Sentiment improved and confidence was slowly restored to financial markets. Global economic growth picked up pace in 2000, supporting equity markets around the world.

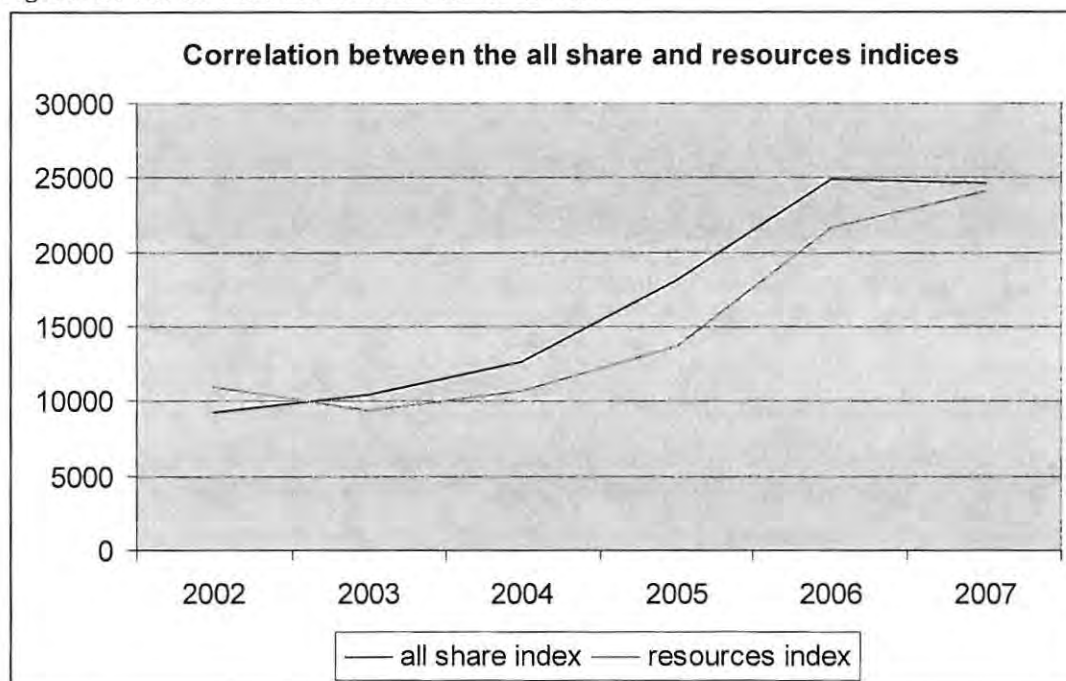
Yet by the second quarter of 2001, signs of a slow down in growth were evident. The September 11 terrorist attacks on the US accelerated this slow-down (SARB, 2000:3).

Sentiment towards South African equities remained positive in the first quarter of 2001, largely due to expectations of continued growth. The total value of shares traded by non-residents in the first 10 months of 2001 reached 31.5% of total sales and purchases. According to the SARB (2001:47), at this level, non-resident participation could have a material impact on price determination and volatility in the domestic share market. While global financial markets declined in the few months leading up to the September 11 terrorist attacks, the South African market continued on its upward trend. However, by September 2001, the local equity market succumbed to global pressures and the monthly average of all shares fell by 11%. Shares recovered slightly by 3% in October 2001 (SARB, 2001:47).

Stock prices recovered strongly in the latter part of 2002. This recovery was led by a recovery in the U.S economy and the emergence of China as a strong contender in the global economy. In particular, the latter factor led to an unprecedented increase in the demand for commodities like gold and metals. China's demand for gold and precious metals fuelled a boom in commodities. This led to an economic expansion in most emerging markets that are exporters of these commodities (SARB, 2004:21). This had a stimulatory effect on South African economy. As a result, South African mining companies reported record profits, which increased their attractiveness as investments. Due to the strong correlation between stock prices and resource prices, the boom in the mining sector was accompanied by sharp increases in stock prices. The equity markets actually experienced one of the biggest booms beginning in late 2004. This boom was led by resource stocks as global demand for commodities surged. Global demand for commodities is generally very unstable; this instability is reflected in commodity prices which are highly volatile. Stock prices tend to overreact, so that a rise in demand results in a big jump in prices. Thus the increase in demand for commodities was matched by even bigger increases in prices which boosted earnings of resource stocks on the JSE. In

addition, given the fact that the all share index top 40 is mostly made up of resource stocks, high commodity prices were generally positive for the overall market.

Figure 4.3: The all share index and the resources index



Source: Inet

Figure 4.3 show the performance of the all share index and the resources index. It is notable that the two indices generally move together. The positive correlation between the two in the past 5 years is irrefutable. The recent strong performance of the all share index was in part led by the strong performance of mining companies. The all share index rose from 8 000 index points in January 2002 to 12 500 points in 2005.

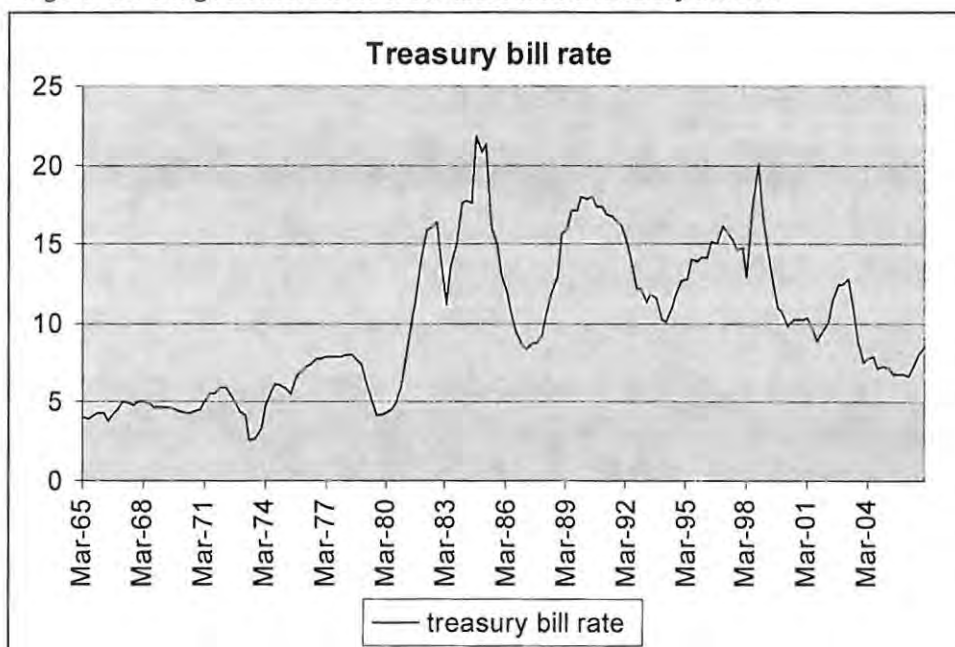
An examination of the graph shows that the index gained about 50% in 2005, rising from 12 500 points to 15 414 index points by the end of August and an astounding year-ending of 18 671 points. The rally continued well into the 2006 with the all share index reaching a high of 19 262 by the end of the first month of 2006 and 22 000 three months into 2006.

In sum, with the exception of the bear market in 1998, South African equities have been on an upward trend. In addition, volatility was observed although it was mostly positive as equities continued their upward trend.

4.3 INTEREST RATE MOVEMENTS

This section discusses the long term behaviour of interest rates in South Africa. The discussion primarily focuses on the three month treasury bill rate (yield). Treasury bill rates are generally more volatile than money market rates. This is due to the fact that while money market rates are set by the Reserve Bank, treasury bill rates are the result of the interaction between the demand and supply of treasury bills. However, since the Reserve Bank's actions influence inflation (which is an input into the determination of treasury bill yields), the two should move closely together (Faure, 2003:236).

Figure 4.4: Long run movement of the three month treasury bill rate



Source: Inet

The long term movement of treasury bill yields was influenced by a combination of internal and external shocks. Prior to 1990, fluctuations in market yields was a reflection

of the political instability that prevailed at the time. In particular, the debt crisis of the late 1980s was responsible for the sharp rise in yields during this period (SARB, 1996). Monetary policy shocks also had a significant influence on treasury bill rates. Before the adoption of inflation targeting, monetary policy was highly erratic; policy was guided by a need to defend the currency rather than maintaining market stability. Therefore, monetary policy shocks were an additional source of shocks causing yields to be highly unstable. Table 4.3 shows the episodes of monetary policy shocks. Monetary policy shocks are defined as an increase in the repo rate by more than 200 basis points.

Table 4.3: Periods of sharp increases in the repo rate

Period	Rate	Change in basis points (bp)
Dec 87 - Oct 89	12.50% - 21.00%	850 bp
Aug 94 - June 95	15.25% - 18.50%	325 bp
May 98 - Sep 98	18.25% - 25.50%	725 bp
Dec 01 - Sep 02	13.00% - 17.00%	400 bp

Source: Dyer and Ince (2006:27)

The sharpest increase in rates was during the debt standstill in the late 1980s, during the Asian crisis in 1998 and finally the Russian debt crisis. Between the period December 1987 and October 1989 the repo rate was raised by 850 basis points. Treasury bill rates also rose sharply in response to higher rates and the increased risk premium on South African debt. While the repo rate was eventually reduced, treasury bill rates remained high due to political instability that prevailed during the period. Treasury bill rates remained high in the earlier part of the 1990, although this was lower than the rates recorded during the debt crisis. The yield on the three month treasury bill fluctuated between 12.5% and 14.22% between December 1994 and December 1995.

In the few months leading to the Asian crisis, conditions in the South African money market were quite stable. A slow-down in the demand for credit and subdued inflation prompted the Reserve Bank to cut the repo rate from 17% to 16% in October 1997.

Notwithstanding the deteriorating conditions in the international financial markets, sentiment in the bond market remained fairly positive. This positive sentiment, as well as the reduction in the repo rate, was generally supportive of bond prices. This caused a decline in bond and treasury bill rates. The tender rate on treasury bills also declined from 15.79% at the end of March to 14.69% at the end of September 1997. Money market rates also followed a similar trend. The prime overdraft rate remained at the 20.25%, since it was raised on 21 November 1996 (SARB, 1997:46).

In 1998, Russia announced a debt standstill followed by a restructuring of all rouble-denominated debt (SARB, 1998: 1). This announcement increased risk aversion to emerging market assets and currencies, which led to a major sell-off in South African bonds, causing a sharp rise in market yields. Bond and treasury bill yields continued to rise as monetary conditions were tightened in order to stabilise conditions in the South African financial markets. The Reserve Bank raised the repo rate from 14.79% in May 1998 through the period of high volatility to settle at a level of 21.86% in October 1998 (SARB, 1998:25). The repo rate was lowered when conditions began to show signs of stabilising. Following the general trend in money market rates, the prime overdraft rate was raised from 18.25% to 20.25% in June 1998.

The repo rate was lowered on several occasions during 2001, beginning in June when it was lowered to 11%, then again in September when it was lowered to 9.50%. The Reserve Bank's increased focus on inflation led the central bank to conclude that risks of missing the inflation target were very low, thus a cut in the repo rate was justified. Following a reduction in the repo rate, money market rates also declined (SARB, 2001:40).

The repo rate was raised four times during the first nine months of 2002, by a 100 basis points on each occasion. The repo rate settled at 13.50% on September 2002. Money market rates generally increased in tandem with the repo rate. However, despite this increase the treasury bill rate declined from 12.78% in October to 12.26% on 26 November (SARB, 2002:40-41).

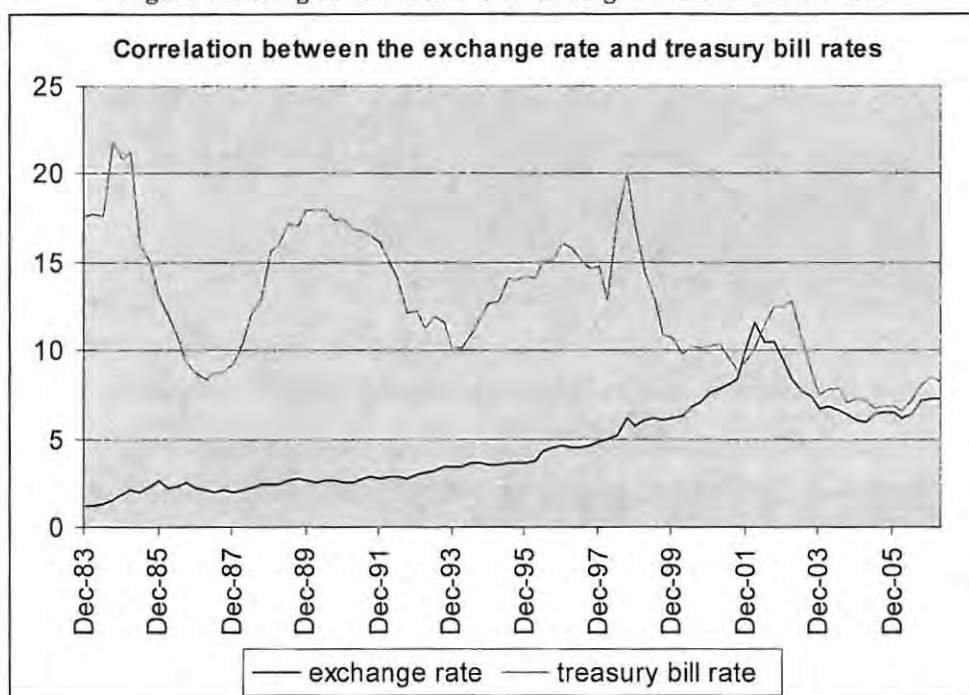
4.4 SUMMARY

Over the period 1996 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 market. As far as interaction of market volatility was concerned, it appears as if the asset markets were the major source of volatility spillovers. This was largely due to the classification of the South African market with the rest of the emerging markets, which increased risk aversion leading to a sell-off in assets. Indeed, it is this sell-off of South African debt securities and equities that was the main cause of instability of the rand (Commission of Inquiry, 2002:1-4). In an act of defence, the Reserve Bank raised interest rates, which increased uncertainty in the debt market. The bank's active defence of the rand increased interest rates volatility and uncertainty in the market.

In the period 2000 to 2006, exchange rate movements were the major source of market instability. From the end of 2001 to the end of 2002 the rand depreciated by 97% against the dollar, before appreciating by 54% by the end of 2004 (see table 4.1 in section 4.1). Interest rates generally moved together with the currency; as a result, volatility in the foreign exchange market led to a coordinated rise in interest rate volatility. The close correlation between exchange rate movements and interest rates is quite strong. With the exception of the 1991-1997¹³ period, exchange rates and interest rates generally moved together. See Figure 4.5 below which shows the correlation between exchange rates and treasury bills rates. At the same time, with the exception of the bear market in 1998, stock prices remained strong. It appears that stock prices were not affected by volatility in the other markets. In fact, the weakening rand was generally supportive of equity markets.

¹³ The presence of exchange controls prior to 1995 could be an explanation for the lack of correlation prior to 1996.

Figure 4.5: Long term movement of exchange rates and interest rates



Source: Inet

Two major observations can be made from a study of volatility trends in the South African financial markets. The first is that volatility is not sustained for very long periods. Financial markets experience periodic volatility shocks that on average last for less than a year. Secondly, volatility seems to be declining in the financial markets. This can be attributed to a more stable and transparent monetary policy that is stability orientated. As far as the identifying the leading market (market which is the source of volatility) is concerned, there is no clear trend. It seems as if each of the markets was a source of heightened volatility at one stage or another. The most important issue that emerged from this analysis is the importance of spillovers and market interactions as a means of spreading instability across the markets.

4.5 CONCLUSION

This chapter discussed the trend and behaviour of the financial markets. Specifically, the chapter examined the volatility trends as well as the drivers of volatility. Volatility trends were examined over the period 1986 to 2006. In terms of the drivers of market volatility,

the financial markets experienced a series of internal and external shocks. These shocks were the major source of market volatility. Next we will formally model volatility and interactions across the markets.

CHAPTER FIVE

METHODOLOGY

5.0 INTRODUCTION

Asset price volatility is generally associated with financial instability. However, as mentioned in section 2.2.2, volatility is not necessarily an indicator of market instability. In fact, volatility is an inherent feature of financial markets and often arises due to changes in expectations of returns or in response to new information (IMF, 2003:62). Although asset price volatility is often harmless, cross correlation of volatility and volatility spillovers are major sources of concern. Volatility spillovers can be attributed to information spillovers and common information shocks across the markets, which are often related to correlation of news flow. For example, news relating to economic fundamentals (GDP, industrial production and inflation) conveys important information about all the markets.

The major source of concern is that volatility spillovers could be a source of systemic risk. As noted in section 1.0, the presence of spillover effects can give rise to contagion. From a financial stability point of view, understanding volatility co-movement and cross correlation cannot be overemphasised. Knowledge about the transmission will improve the effectiveness of monetary policy since it ensures that policies are directed at the market which is the cause of the instability.

The modelling and forecasting of stock markets and exchange rate volatility has received a great deal of attention in the literature (see for example Chou (1988), Lamoureux and Lastrapes (1990) and Tse (1998)). However, the modelling of volatility interaction and the transmission of volatility within the financial system remains an under researched area. Nevertheless, there is a growing interest in modelling volatility transmission. The few studies investigating this particular issue mainly focus on a single market, for instance,

the stock market or the foreign exchange market. For example, Brooks and Raganathan (2003) examine volatility spillovers across the Chinese stock markets, while Bala and Premaratne (2004) examine volatility spillovers across international stock markets. Very little research has been done to examine volatility transmission across the entire financial system. One such study that examines volatility spillovers across the financial system is the work of Hurditt (2004).

With regard to methodology, by far the most popular method is the VAR. The VAR was used in Brooks and Raganathan (2003), Bala and Premaratne (2004). These studies estimated a combination of a multivariate VAR and a GARCH model. Yang and Doong (2004) also employed a multivariate version of Nelson's EGARCH model to examine volatility spillovers across the G-7 countries. A similar approach was adopted by Hurditt (2004). However, this study employed a multivariate version of GARCH model, which was proposed by Baba, Engle, Kraft and Kroner (BEKK) in 1991, the GARCH-BEKK.

An analysis of volatility co-movement could also be achieved through cointegration analysis. Arango *et al.*, (2001:5) employed the cointegration approach to examine co-movement between stock prices and exchange rates. The major limitation of cointegration analysis is that the method is concerned with modelling the long run co-movement of the variables. The long run relationship does not tell us much about the impact of volatility shocks across the market, or indicate the relative importance of volatility shocks.

This chapter discusses the methodology employed in this study. This will entail a discussion of econometric models that are available to model volatility and volatility spillovers. The chapter is organised as follows: section 5.1 reviews econometric methods that are available to model volatility and volatility spillovers; section 5.2 discusses the data and estimation issues and finally section 5.3 concludes.

5.1 EMPIRICAL MODELS

Several models are available to model market volatility. The ARCH family of models was specifically developed to model financial market volatility. Although not yet common in financial industry, the ARCH models enjoy widespread application in the literature. With regard to the analysis of volatility interaction, most studies employ the multivariate VAR. These models are discussed in the next section.

5.1.1 Autoregressive conditional heteroskedasticity model

The development of the ARCH models was a major breakthrough in the modelling of volatility. The ARCH models presented an alternative measure to the standard deviation and historical volatility models that can be applied in financial decision making. The most significant contribution of the ARCH models is the fact that the models were designed to deal with time series that are heteroskedastic. Heteroskedasticity means that unlike the normal distribution, which assumes a constant variance, the variances are actually time dependent. Heteroskedasticity is a well known feature of market returns. In addition to heteroskedasticity, another feature of market returns is autocorrelation. Autocorrelation describes a pattern of volatility clustering, that large changes in volatility of either sign are followed by larger changes and small changes (of either sign) are followed by smaller changes (Brooks, 2003:445).

Developed by Engle (1982), the ARCH model is unique in that it specifies the variance of the error term in a regression equation as conditional on the lagged squared errors. The model exhibits periods of relative tranquility and volatility, effectively capturing this volatility clustering characteristic so common to economic and financial time series data. (Brooks, 2003:445).

The ARCH model is useful because it does not assume that the variance of errors is constant and therefore describes how the variance of the errors evolves over time

Moreover, under the ARCH model the autocorrelation in volatility is modelled by allowing the conditional variance of the error term, σ_t^2 , to depend on the immediate past value of the squared error (Brooks, 2003: 446). An advantage of the ARCH model is the fact that volatility can be estimated based on historical data, effectively simplifying the measurement and estimation of volatility (Engle, 2001:5). This simplifies the work of the researcher since only the historical data is required. The simple ARCH model can be represented as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 \quad (5.1)$$

The above model is known as an ARCH (1) since the conditional variance depends only on one lagged squared error. The model is incomplete without specifying the mean model (Brooks 2003:447). Including the mean model, the ARCH model can be represented as follows:

$$y_t = \beta_1 + \beta_2 x_{1t} + \beta_3 x_{2t} + u_t \quad (5.2)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 \quad (5.3)$$

This model can be extended to the general case where the error variance depends on q lags of the squared errors, which would be know as the ARCH (q) model.

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-2}^2 + \alpha_3 u_{t-3}^2 \dots + \alpha_q u_{t-q}^2 \quad (5.4)$$

The conditional variance is often denoted as h_t , so that the model above now becomes:

$$y_t = \beta_1 + \beta_2 x_{1t} + \beta_3 x_{2t} + u_t \quad (5.5)$$

$$h_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-2}^2 + \alpha_3 u_{t-3}^2 \dots + \alpha_q u_{t-q}^2 \quad (5.6)$$

Where β_1 , β_2 and β_3 are parameters to be estimated, y_t is the conditional mean and u_t is the error term. In the variance equation $\alpha_0, \alpha_1, \alpha_2$ and α_3 are parameters to be estimated and h_t^2 is the conditional variance, while q is the number of lags to be included and u_t are innovations. In the ARCH (q) model, the volatility is a function of (q) past squared returns. For the ARCH to be well defined, the parameters must satisfy $\alpha_0 > 0$ and $\alpha_1 > 0 \dots \alpha_q > 0$. Equation (5.6) therefore gives the conditional variance equation in the ARCH model. The empirical estimation of ARCH (q) is quite challenging, since the model requires the estimation of many lags.

The generalised ARCH (GARCH) proposed by Bollerslev (1986) and Taylor (1986) presents a simplified model to deal with the lag length. According to Bollerslev *et al.*, (1992:10) an appealing feature of the GARCH model is its time series properties. The authors proved that by rearranging the terms the model can be interpreted as an ARMA model for the errors ε_t^2 . They argued that this idea can be used in the identification of p and q , although $p = q = 1$ is often sufficient. In its simplest form, the GARCH model can be expressed as:

$$h_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta h_{t-1}^2 \quad (5.7)$$

Equation 5.7 presents a GARCH (1, 1) which allows the conditional variance to be dependent upon its own lags and a lag of the squared errors. The h_t^2 coefficient is known as the conditional variance since it is a one period ahead estimate of the variance and u_{t-1}^2 is the squared errors. The term u_{t-1}^2 represents the ARCH term which measures volatility in the past period, while, h_{t-1}^2 is the GARCH term representing the last period's conditional variance. Thus, using the GARCH model, the current fitted variance can be interpreted as a weighted function of the long term average value (α_0) and information about the volatility in the previous period u_{t-1}^2 and the fitted variance from the model in the previous period h_{t-1}^2 . The GARCH model is conditionally heteroskedastic but has a

constant unconditional variance (Engle, 2001:5). The GARCH (1, 1) model can be extended to a GARCH (p, q) where the current conditional variance is parametrised to depend upon (q) lags of the squared errors and p lags of the conditional variance.

The GARCH model is the most widely used model from the ARCH family of models and is regarded as more parsimonious while avoiding over fitting. Brooks (2003: 453) argues that the GARCH (1, 1) model is sufficient to capture volatility clustering in the data and a higher order model is rarely required. However, the GARCH (1, 1) is not without its limitations. In the first place, the GARCH (1, 1) cannot guarantee non-negativity; in this case, restrictions on the parameters are necessary to ensure that the conditional variance is positive (Brooks, 2003:468). Secondly, in certain cases, the GARCH model may not account for all volatility clustering and kurtosis in a series. For example, exchange rate volatility may be more persistent than what is captured by the basic ARCH/GARCH models (Baillie, *et al.*, (1996) in Tse, (1998:49)). In this case, another model would have to be estimated that would capture all the volatility clustering in the data. A third problem with the model is that it does not allow any direct feedback between the conditional variance and the mean (Brooks, 2003: 469). Finally, the GARCH model cannot account for asymmetry in volatility. In the stock market, good news and bad news often have an asymmetric impact on volatility. Bad news (negative shock) causes volatility to rise by more than a positive shock of the same magnitude (Bala and Premeratne, 2004:8).

Extensions to the basic GARCH were suggested as a consequence of the above mentioned problems. These include the model by Glosten, Jaganathan and Runkle (GJR-GARCH) which is also known as the TARARCH, Exponential GARCH (EGARCH), Integrated GARCH (IGARCH), and the GARCH in mean (GARCH-M). The GARCH-M model was developed to deal with the issue of lack of feedback between the variance and the mean. Asymmetric models like the GJR-GARCH and the EGARCH were developed to capture the asymmetric impact of volatility shocks (Brooks, 2003: 468). A brief review of these models follows.

The GJR model or the TARARCH was introduced by Zakoian (1990) and Glosten, Jagannathan and Runkle (1993). The TARARCH is a simple extension of the GARCH with an additional term to account for possible asymmetries. The GARCH (1, 1) assumes a symmetric response of volatility in response to positive and negative shocks. However, it is argued that negative shocks (bad news) cause volatility to rise by more than positive shocks (good news) of the same magnitude. In the stock market, the asymmetric response can be attributed to leverage effects. A negative shock (bad news) that causes a decline in stock prices will increase the firm's debt to equity ratio. This leads to an increase in the risk of equity investments, increasing stock price volatility (Bala and Premeratne, 2004:8).

In this model, the conditional variance is now given by:

$$h_t^2 = \alpha_0 + \alpha_1 \varepsilon_t^2 + \beta h_{t-1}^2 + \gamma \varepsilon_{t-1}^2 I_{t-1} \quad (5.8)$$

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

For leverage effect to exist, we would see $\gamma > 0$. In this model, good news ($\varepsilon_t > 0$), and bad news ($\varepsilon_t < 0$), have differential impacts on the conditional variance. Good news will have an impact of α , while bad news has an impact of $(\alpha + \gamma)$. If $\gamma > 0$ then it implies that leverage effect exists, however, if $\gamma \neq 0$, then the impact is asymmetric. Thus the markets will be more volatile when there is bad news or good news (Bala and Premeratne, 2004:8).

The EGARCH was proposed by Nelson (1991) to capture leverage effects in the conditional variance. Nelson argued that downward movements (fall in returns) are more influential in predicting volatility than upward movements. According to Bala and Premeratne (2004:7), the EGARCH model represents a more successful method of

modelling the excess kurtosis in stock indices based on a generalised exponential distribution.

In this model the conditional variance equation can be expressed as:

$$\ln h^2_t = \omega + \beta \ln(h^2_{t-1}) + \gamma \frac{\varepsilon_{t-1}}{\sqrt{(h^2_{t-1})}} + \alpha \left[\frac{\varepsilon^2_{t-1}}{\sqrt{h^2_{t-1}}} - \sqrt{2\Pi} \right] \quad (5.9)$$

The model is asymmetric because the term $\gamma \frac{\varepsilon_{t-1}}{\sqrt{(h^2_{t-1})}}$ is typically negative, which results in positive returns generating less volatility than negative shocks. The main advantage of the model over the GARCH is that it ensures that the conditional variance is positive. Since the log of (h^2_t) is modeled, even if the parameters are negative, $(\ln h^2_t)$ will be positive. This feature eliminates the non negativity constraint associated with the GARCH (1, 1). Secondly, asymmetry is also allowed in the EGARCH model since if the relationship between volatility and returns is negative, γ will be negative (Brooks, 2003: 470).

The GARCH-M model has enjoyed widespread use in finance, because it provides a practical way of modeling risk and return. Engle, Lilien and Robins (1987) (in Brooks, 2003:480) proposed a GARCH-M model where the conditional variance enters into the conditional mean equation. The model is represented as follows:

$$Y_t = \mu + \delta h_{t-1} + e_t, \quad e_t \sim N(0, \sigma^2_t) \quad (5.10)$$

$$h^2_t = \alpha_0 + \alpha_1 e^2_{t-1} + \beta h^2_{t-1} \quad (5.11)$$

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 the risk premium.

5.2.1 The vector autoregressive (VAR) model

The inter-relationships between financial markets and market volatilities was examined by Hurditt (2004). In particular, the impact of volatility in one market on volatility in another, as well as the transmission of shocks across the entire market, is of primary interest in this study. An analysis of these market dynamics will shed some light on volatility spillovers. The VAR is particularly useful in this regard. Using the VAR, market dynamics can be analysed within the context of the impulse response and variance decomposition. This analysis is quite useful in that it shows the relative importance of shocks originating in one market in influencing volatility in another market.

The VAR model was developed by Sims (1980) as a generalisation of the univariate autoregressive model. In the VAR model, there is no distinction between endogenous and exogenous variables so that each of the variables depends on different combinations of the lagged values of all the variables in the system. The VAR model is a useful tool since the researcher does not need to specify which variables are endogenous or exogenous. The model also allows for a richer analysis and is able to capture more features of the relationship since it allows variables to depend on more than just its lagged values (Brooks, 2003: 330-340). The VAR can be represented as follows (see Bala and Premeratne (2004:9)).

$$Z(t) = C + \sum_{s=1}^m A(s)Z(t-s) + e(t) \quad (5.12)$$

The limitations of the VAR include the atheoretical nature of the model, intricacy of interpreting the VAR coefficients, a large number of coefficients to be estimated and a lack of theoretical guidance with regards to lag selection. Lag selection is important as the results will be influenced by the number of lags included in the model. The Bayesian information criteria (BIC), Aikake information criteria (AIC) and the Schwartz Bayesian Criterion (SBC) are methods that can be employed to select the appropriate lag (Brooks, 2003: 333).

By far the most appealing feature of the VAR model is the impulse response function and the variance decomposition that can be derived after estimation. These tools allow the researcher to analyse the short run dynamic relationship between the markets volatilities thereby assessing the impact of short run shocks on volatilities as well as the length of time it takes for these shocks to work through the system. According to Bala and Premeratne (2004:9) the estimated VAR can be inverted to form a moving average system as expressed as follows:

$$Z(t) = \sum_{s=0}^m B(s)e(t-s) \quad (5.13)$$

Where $Z(t)$ is the linear combination of current and past one-step-ahead forecast errors or innovation. The i, j th component of the $B(s)$ shows the response of the i th market in s periods after a unit random shock in the j th market. The $e(t)$ are serially uncorrelated, although they may be contemporaneously correlated. In order to capture the pure responses, it is important to transfer the error terms. A lower triangular matrix V is chosen to obtain the orthogonalized innovations u from $e = VU$. The i, j th component of $B(s)V$ represents the impulse response of the i th market in the s periods to a shock of the standard error in the j th market:

$$Z(t) = \sum_{s=0}^k B(s) - Vu(t-s) \quad (5.14)$$

The orthogonalization also provides $C^2_{ij}(s)$, which is the component of the forecast error variance in the $t+1$ step ahead forecast of Z_i that accounts for innovations in Z_j . The decomposition of the forecast error variance gives a measure of how important one variable is in generating fluctuations in its own and other variables (Bala and Premeratne, 2004:10).

5.2 DATA AND ESTIMATION ISSUES

Achieving the objectives of the study entails estimating market volatilities and using these estimates to model volatility spillovers. This section discusses the data and estimation techniques that will be employed to achieve this objective.

5.2.1 Data

The study utilises weekly closing data of stock prices (all share index), exchange rate (spot rand/dollar exchange) and interest rates (three month treasury bill rate). The sample spans the period February 1996 to July 2006. It is a well known fact that stock prices, exchange rates and interest rates are non stationary. However, the variables included in a VAR are required to be stationary in order to carry out hypothesis testing and significance tests. Although the levels of variables are not stationary, the first differences (returns) are stationary¹⁴. In practice, market returns are used quite extensively as a proxy for market movements. See for example, Bala and Premeratne (2004:4), Brooks and Ragunathan (2003:749), and Hurditt (2004: 12). Given the non-stationary nature of data, the logged first differences of stock prices, exchange rates and treasury bill yields are modelled. The log of stock returns (LOGALL) is a proxy for market returns. The log of exchange rates (LOGER) represents the average depreciation and appreciation of the rand against the USD. The log of three month treasury bill rate (LOGTBR) measures the percentage change in the treasury yield, an approximation of cash returns.

5.2.2 Unit root tests

It is generally possible to infer the properties of the series through graphical analysis and by examining the correlogram. However, in practise, the autocorrelation function (acf) of a stationary but highly persistent series is closely related to that of a non-stationary series

¹⁴ The first differences of each of the series are an approximation of market returns.

(Brooks, 2003:377). This can be quite misleading, resulting in incorrect inference. In order to test for unit root, a formal testing procedure should be adopted. The Dickey Fuller (DF), Augmented Dickey Fuller (ADF) and the Philip and Perron (PP) tests are the most popular methods. The DF and the PP tests are based on the null hypothesis of unit root ($\Phi = 1$) against the alternative of a stationary white noise process ($\Phi < 1$) in the following regression¹⁵:

$$y_t = \Phi y_{t-1} + u_t \quad (5.15)$$

The Dickey Fuller test may be applied in three general forms, (i) the general model specified above, a random walk against a stationary autoregressive model (AR) (1); (ii) unit root test on the regression including a constant. This is a test for random walk against a stationary AR (1) with drift; and, (iii) Regression 5.15 with an intercept and a trend. This entails a test of random walk against the alternative of an AR (1) with a constant and a deterministic trend (Brooks, 2003:377-382).

The Philip and Perron test is similar to the DF test, but it is a more comprehensive method of testing for unit root. The test incorporates an automatic correction to the DF test to allow for autocorrelated residuals. The major criticism of the unit root tests is that their power is low if the process is stationary but has a root close to 1. In addition, the DF and the PP test are biased towards non-stationarity since under these tests the null hypothesis is of non-stationarity. Brook (2003:382) proposes the use of both non stationarity tests (such as the DF and PP) as well as the stationarity test like the one proposed by Kwiatkowski et al., (1992) (KPSS). Stationarity tests have stationarity under the null hypothesis, thus reversing the null and alternative hypothesis under the DF and the PP tests. Thus, under the stationarity test, the data will appear stationary by default if there is limited information in the sample. Thus using the KPSS test complements the results of the DF and PP tests (See Brooks, 2003: 382).

¹⁵ In practice, the following model is used, due to its simplicity and ease of interpretation: $\Delta y_t = \psi y_{t-1} + u_t$,

So that a test of $\Phi = 1$ is equivalent to testing $\psi = 1$ (since $\Phi - 1 = \psi$).

5.2.3 The mean equation

The starting point of modelling volatility is to specify the mean equation. To determine the flow of information between the markets, it is assumed that distribution of returns follows an AR process of order (q). Information flow within each market has significant implications for market efficiency. Using the AR (q) model allows the researcher to also test for market efficiency. In this case, an efficient market is defined as the market that incorporates information much faster than the other markets. The AR (q) model can be represented as follows:

$$R_t = \alpha_0 + \rho_1 R_{t-1} + \rho_2 R_{t-2} + \dots + \rho_q R_{t-q} + e_t \quad (5.17)$$

where

R_t = represents market returns

α_0 and ρ_i are coefficients to be estimated

The presence of information spillovers in the means of returns was noted by Brooks and Ragunathan (2003:749). Information spillovers imply strong linkages across the markets. However, the transmission of information across the markets is also important for market efficiency. An efficient market is a market that incorporates all relevant information (which includes information originating in the other markets). To measure market linkages the specified mean AR (q) model is expanded to include the lags of returns of the other two markets. This specification also allows us to test for both forms of market efficiency. This suggests estimating the following multiple regression model:

$$R_t^{SM} = \alpha_0 + \rho_1 R_{t-1}^{SM} + \rho_2 R_{t-2}^{SM} + \delta_1 R_{t-1}^{ER} + \delta_2 R_{t-2}^{ER} + \gamma_1 R_{t-1}^{TBR} + \gamma_2 R_{t-2}^{TBR} + \varepsilon_t \quad (5.18)$$

$$R_t^{ER} = \alpha_0 + \rho_1 R_{t-1}^{SM} + \rho_2 R_{t-2}^{SM} + \delta_1 R_{t-1}^{ER} + \delta_2 R_{t-2}^{ER} + \gamma_1 R_{t-1}^{TBR} + \gamma_2 R_{t-2}^{TBR} + \varepsilon_t \quad (5.19)$$

$$R^{TBR}_t = \alpha_0 + \rho_1 R^{SM}_{t-1} + \dots + \rho_{20} R^{SM}_{t-20} + \delta_1 R^{ER}_{t-1} + \dots + \delta_{20} R^{ER}_{t-20} + \gamma_1 R^{TBR}_{t-1} + \dots + \gamma_{20} R^{TBR}_{t-20} + \varepsilon_t \quad (5.20)$$

Where R^{SM}_t , R^{ER}_t and R^{TBR}_t represents stock, foreign exchange and money market returns. The ρ , δ and γ are coefficients to be estimated and ε_t is the error term. The coefficient ρ corresponds to the lag of stock returns, which measures information spillovers originating from the stock markets; the coefficient δ corresponds to the lag of exchange rates and thus measures information spillovers from the foreign exchange market to the other two markets. The coefficient γ measures information spillovers originating in the money market. The optimal lag length should be guided by empirical evidence on what is observed in the market place. In practice, the response of current prices to past information can vary from 4 lags (1 month) up to 20 lags (5 months, depending on the nature of the market). In addition, a longer lag is often required to capture the dynamic relationship between the variables ((Friedman and Shachmurove, 1997) in Bala and Premeratne (2004:18)). The estimation experimented with 10 and 20 lags. The model was based on 20 lags; however, only the significant lags are reported.

5.2.4 Testing for ARCH effects

To estimate an ARCH model, there must be sufficient evidence of heteroskedasticity (ARCH effect) in the data. The presence of ARCH effects in the data does not invalidate standard inference, but ignoring it may result in a loss of efficiency (e-views manual version 4:2002). There are two tests that may be employed to test for heteroskedasticity: the ARCH LM and the white heteroskedasticity tests. The white heteroskedasticity test applies a similar testing procedure to the ARCH LM; thus it will not be discussed in this section.

The ARCH LM test is the most widely used method to test for ARCH effects. The ARCH LM is a Lagrange Multiplier (LM) test for heteroskedasticity. To test for ARCH effects a regression of the squared residuals against a constant and the lagged squared residuals up to lag q is estimated. The null hypothesis is of no autocorrelation in the data. Two test

statistics are reported, the F statistic and the Observations*R-squared (follows an χ^2 distribution). A significant test statistic gives evidence of ARCH effects in the data (eviews manual version 4:2002). The ARCH LM test was employed to test for ARCH effects.

5.2.5 Univariate GARCH, TARARCH and EGARCH estimation

For each of the markets, a univariate ARCH model is estimated. As mentioned in section 5.2.3, to account for cross correlation across the markets a multiple regression model of market returns is specified as the mean model in this estimation. This approach is similar to that employed by Brooks and Ragunathan (2003:750-751). To model the conditional variances, the study employed the GARCH (1, 1). However, the basic GARCH (1, 1) does not account for asymmetry in the conditional variance. As mentioned in section 5.1.1, asymmetry is a feature of stock market volatility. Extensions of the GARCH (1, 1) (for example the TARARCH (GJR) and EGARCH) have been developed specifically to deal with the issue of asymmetry.

Therefore, in contrast to Brooks and Ragunathan's (2003:750) approach, the current study experimented with three ARCH models. These are: the GARCH (1, 1), TARARCH, and the EGARCH. This approach is similar to Bala and Premeratne (2004: 7-8). The analysis entailed specifying and estimating the following models:

$$h^2_t = \alpha_0 + \alpha_1 u^2_{t-1} + \beta h^2_{t-1} \quad (5.21)$$

$$h^2_t = \alpha_0 + \alpha_1 \varepsilon^2_t + \beta h^2_{t-1} + \gamma \varepsilon^2_{t-1} I_{t-1} \quad (5.22)$$

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

$$\ln h^2_t = \omega + \beta \ln(h^2_{t-1}) + \gamma \frac{\varepsilon_{t-1}}{\sqrt{(h^2_{t-1})}} + \alpha \left[\frac{\varepsilon^2_{t-1}}{\sqrt{h^2_{t-1}}} - \sqrt{2\Pi} \right] \quad (5.23)$$

Rather than estimate the full mean model (with 20 lags) the estimation is based on the significant lags from the estimated equation (the mean model) as discussed above.

An interesting issue worth investigating is the long term trend of market volatilities. The results are compared against the empirical evidence of long term trends in each of the variables as discussed in Chapter Four. To measure volatility trends, each of the conditional variance series is modeled against a constant and a time parameter. This entailed estimating the following model:

$$y_t = \alpha + \varphi_t \quad (5.24)$$

Where y_t is the conditional variance in each market and t is the time parameter. The α coefficient is the constant and φ is the parameter to be estimated. In this model, an increase in market volatility is evidenced by a positive φ parameter while a negative parameter is evidence of a decrease in market volatility. In Brooks and Ragunathan (2003:750-752), the estimated variances are used to identify a model for volatility spillovers. In this model, the conditional variances are included in a VAR as endogenous variables. Spillovers are measured by examining the significance of the coefficients on the lagged conditional variances. A significant lag implies the presence of spillovers from that market to the market represented by the dependent variable. Therefore, following Brooks and Ragunathan (2003:751), the following models were estimated:

$$h^{SM}_j = \psi_0 + \psi_1 h^{SM}_{t-1} \dots \psi_{20} h^{SM}_{t-20} + \theta_1 h^{ER}_{t-1} \dots \theta_{20} h^{ER}_{t-20} + \lambda_1 h^{TBR}_{t-1} \dots \lambda_{20} h^{TBR}_{t-20} + \varepsilon_t \quad (5.25)$$

$$h^{ER}_j = \psi_0 + \psi_1 h^{SM}_{t-1} \dots \psi_{20} h^{SM}_{t-20} + \theta_1 h^{ER}_{t-1} \dots \theta_{20} h^{ER}_{t-20} + \lambda_1 h^{TBR}_{t-1} \dots \lambda_{20} h^{TBR}_{t-20} + \varepsilon_t \quad (5.26)$$

$$h^{TBR}_j = \psi_0 + \psi_1 h^{SM}_{t-1} \dots \psi_{20} h^{SM}_{t-20} + \theta_1 h^{ER}_{t-1} \dots \theta_{20} h^{ER}_{t-20} + \lambda_1 h^{TBR}_{t-1} \dots \lambda_{20} h^{TBR}_{t-20} + \varepsilon_t \quad (5.27)$$

where h^{SM}_j , h^{ER}_j , h^{TBR}_j represent the conditional variances in the stock, foreign exchange and the money markets. The dependent variable is the volatility of a single market which is a function of the other market volatilities (independent variables). Volatility spillovers are identified by examining the significance of the coefficients of the lagged conditional variances of the other markets. A significant lag implies the presence of spillovers originating in that market to the market represented by the dependent variable.

The VAR has several advantages. As noted in section 5.2.1, the most useful tools of the VAR are the impulse responses and variance decomposition. These tools were employed by Bala and Premaratne (2004:17) to examine the transmission of shocks across international stock markets. The final step of the analysis involved generating the impulse responses and the variance decomposition, which were generated for a forecast period of 10 weeks.

5.3 CONCLUSION

The chapter discussed the empirical models that are employed in this study. In summary, the ARCH models represent a significant shift in the modeling of volatility. Although various models are available, it is argued that the GARCH (1, 1) model is the most efficient. However, the GARCH (1, 1) cannot account for the asymmetric impact of volatility (observed in the stock market) and cannot account for all the excess kurtosis.

In practice, model selection is often not that obvious. Typically, the researcher often has to experiment with various models before an appropriate model is identified. The data, however, provides a guide to the choice of the final model. With regards to the modelling of volatility spillovers, the analysis employs the VAR framework. The most significant feature of the model is that it allows for analysis of the short run dynamic across the markets. Such an analysis is useful in examining the transmission of shocks and

propagation mechanism, all of which are critical in the development of a crisis. The next section presents the empirical results and findings of the study.

CHAPTER SIX

EMPIRICAL RESULTS

6.0 INTRODUCTION

This chapter presents the empirical results and findings of this study. Empirical studies have proven that financial market volatilities are highly persistent (Bala and Premeratne, 2004:16). In particular, exchange rate volatility displays a high level of persistent and an increasing trend over time. Frommel and Menkhoff (2003:877) argue that volatility might be regime specific, i.e. the floating exchange rate regime is characterised by higher volatility than the fixed exchange rate system. In the stock market, the impact of volatility shocks is asymmetric; this implies that negative shocks generate higher volatility than positive shocks (Bala and Premeratne, 2004:18). This chapter tests these hypotheses and presents the results. Specifically, the focus is on examining the trend in market volatilities alongside theoretical expectations. That is, volatilities will be examined to determine whether or not they display these unique features - persistence and asymmetry.

As will be recalled from the previous chapters, an analysis of volatility spillovers is the principal objective of this study. An understanding of volatility spillovers and the transmission of volatility shocks across the financial markets is critical to ensure the effectiveness of monetary policy in preventing financial instability. Thus, a major focus of this study and this chapter in particular is the modelling and analysis of volatility spillovers. This chapter reports the results of this analysis.

The results of the estimated models indicate some spillovers in the mean of returns, although they are not that significant. However, significant spillovers in the second moment (conditional variances) of returns were found. The money market accounts for most of the spillover effects in both the stock market and the foreign exchange market.

No spillover effects from both the foreign exchange and the stock market were found in the money market.

The chapter is organised as follows: section 6.1 discusses the sample and statistical properties of each of the variables; section 6.2 presents the results of estimating the various models and the hypothesis testing; 6.3 discusses estimated models of volatility spillovers and the final section 6.4 is the conclusion.

6.1 DESCRIPTIVE STATISTICS

The study's sample comprises weekly closing data of stock prices, exchange rates and interest rates. This data spans a ten year period dating from January 1996 to July 2006. Weekly data was used rather than daily or monthly data, because it does not contain too much noise and it is sufficient to capture the properties of financial data (Yang and Doong, 2004:141). The all share index is used to measure stock prices and returns. The Index contains the 162 companies listed on the JSE securities exchange. This Index is appropriate as it reflects the general movements of stock prices on the JSE. To measure exchange rates, the nominal rand exchange rate to the USD is used. Nominal exchange rates were used because the series reflects the impact of capital inflows and outflows on exchange rates. To measure interest rate movements, the three month treasury bill rate is used. Treasury bill yields are determined through the interaction of supply and demand. Thus, changes in yields are a reflection of general market movements. All data is converted into logs before estimation. The data is sourced from Inet and Bloomberg. Table 6.1 presents the summary statistics

Table 6.1: Summary statistics

	Stock Returns	Interest rates	Exchange rates
Mean	9278.486	11.27	6.672775
Median	8362.551	10.63	6.327000
High	21822	22.30	12.68090
Low	4319	6.49	3.62
Standard Deviation	3770.451	3.47	1.80
Skewness	1.4920	0.48	0.907
Kurtosis	4.863097	2.53	3.65
Jarque Bera	284.6350***	27.15***	85.54***

* indicates significance at the 10% level

** indicates significance at the 5% level

*** indicates significance at the 1% level

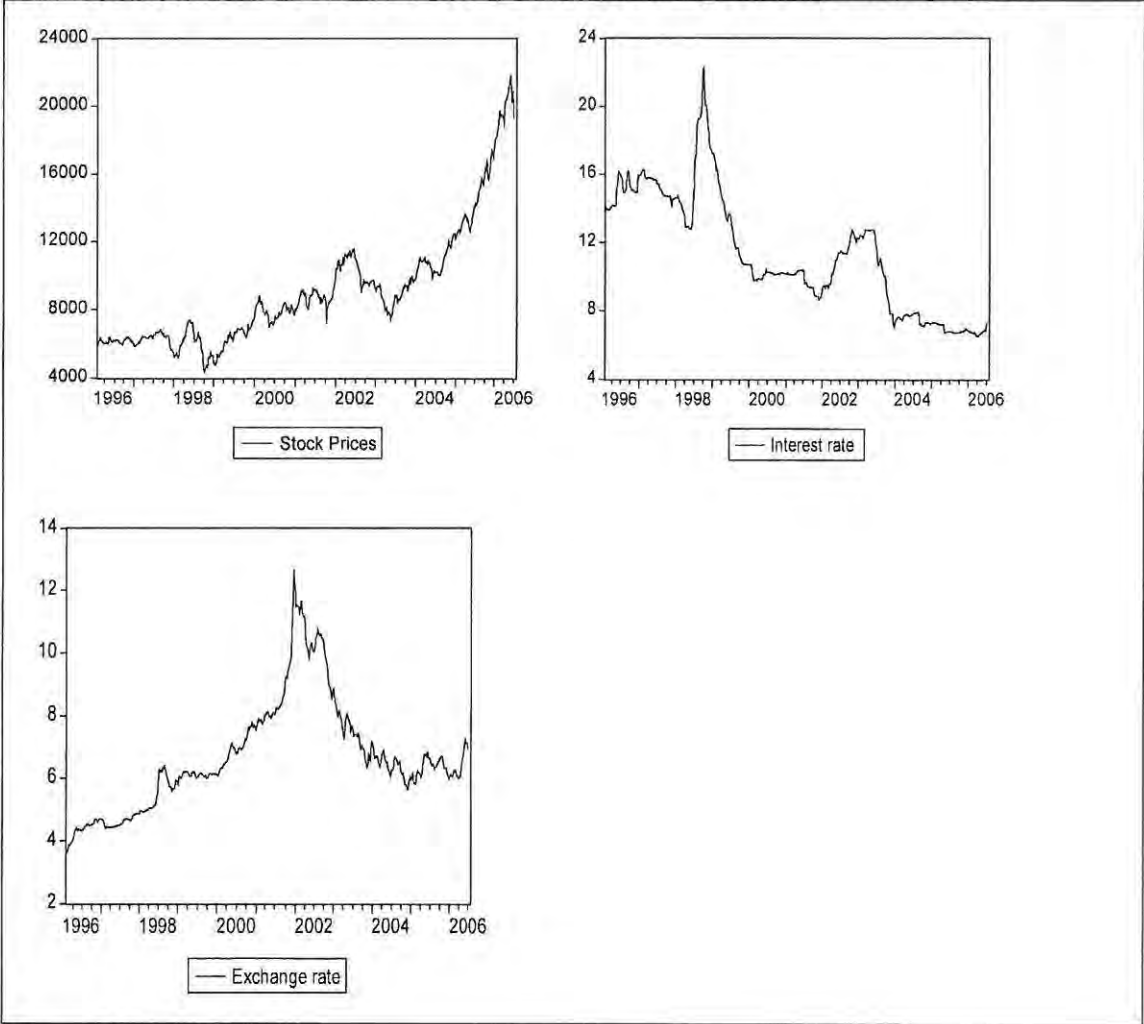
A general observation is that all the series display features of non-normality. The Jarque Bera statistic is highly significant for all the series, which leads to a rejection of the null hypothesis of normality for all the series. All the series exhibit excess kurtosis, which is a measure of the degree to which a distribution is more or less peaked than the normal distribution. If Kurtosis¹⁶ is greater than 3, the distribution is said to be leptokurtic (peaked with fatter tails) relative to the normal distribution. On the other hand, Kurtosis of less than 3 implies that the distribution is platykurtic (flatter than the normal distribution).

The all share index is positively skewed and has excess positive kurtosis (leptokurtic). The Jarque Bera statistic is highly significant, which implies a rejection of the assumption of normality. The distribution of treasury-bills rate shows very little positive skewness (it is almost symmetrical). However, the Jarque bera statistic is significant, rejecting normality. Kurtosis is less than 3, which implies that the distribution is platykurtic. The distribution for exchange rates shows evidence of positive skewness. The exchange rate also exhibits excess kurtosis, implying that the series is leptokurtic.

¹⁶The normal distribution has kurtosis equal to 3.

The graphs of each series for the entire sample period are presented below. The series appear to be characterised by a stochastic trend which is a common feature of non stationary series (Brooks, 2003:372). While graphical analysis is useful, it is more appropriate to conduct formal unit root tests to assess the time series behaviour of each of the series.

Figure 6.1: The all share index, Treasury bill rate and exchange rate over the sample period



Source: Inet

6.2 RESULTS

6.2.1 Unit root tests

An examination of the correlogram for the stock returns shows a geometrically declining autocorrelation coefficient (acf) and a partial correlation coefficient (pacf) that declines to zero after the first lag. The correlogram for the interest rates shows an acf coefficient that declines gradually and a pacf coefficient that declines to zero after three lags. The correlogram for exchange rates also showed a similar pattern to that of interest rates, however its pacf coefficient dies after the second lag. The Q-statistic is often used as a test of whether the series is white noise, under the null hypothesis of no autocorrelation (series white noise). The Q-statistic for all the series is highly significant, rejecting the null of no autocorrelation (see graphs 6.1, 6.2 and 6.3 in the appendix).

The properties of the series are generally suggestive of the presence of autocorrelation in the data, which could be a sign that the series is non-stationary. In addition, the pattern of the acf suggests that the underlying distribution of returns is characterized by an AR (q), which means that the AR mean model would be appropriate. While the correlogram is a useful way to check whether the series is stationary or not, a more formal test is usually required. The next section reports the results of Dickey Fuller (DF) and Philip and Perron (PP) unit root tests.

The results of both the DF and PP tests failed to reject the null hypothesis of a unit root in all the series. However, the null was rejected after the first differences of returns. Therefore, there is sufficient evidence which suggest that the series are integrated of order one I(1). Table 6.2 presents results for the DF and PP unit root tests.

Table 6.2: Unit root tests results

Series	DF		PP	
	Level	First difference	Level	First difference
All share index	1.56	-4.22**	0.13	-21.83***
Interest rate	-0.30	-5.50**	-1.01	-19.41***
Exchange rates	-0.07	-17.19***	-2.21	-17.53***

* indicates significance at the 10 % level

** indicates significance at the 5% level

*** indicates Significance at 1% level

6.2.2 Spillovers in the mean (level) of returns

The presence of spillovers in the mean of market returns is documented by Brooks and Raganathan (2003:747-752) who found significant information spillovers across Chinese stock markets. In the current study, spillovers in the mean of returns (levels) are interpreted as evidence of a significant relationship between the financial markets, which implies that there are strong linkages between the financial markets

Market linkages arise from two main sources: (1) common information that simultaneously alters expectations about market returns, generates trading and volatility across the financial markets (Fleming, Kirby and Ostdiek, 1998:112). Stock prices, interest rates and exchange rates are all driven by economic fundamentals such as GDP and inflation. A change in economic fundamentals alters expectations about returns, generating trading and volatility across the market. The increased trading activity will be reflected in market prices and returns, which represent broad market movements. Thus, common information leads to a correlation in market returns which in this case is interpreted as evidence that there are similar forces driving the markets which cause the markets to move together (positive correlation of market returns).

(2) A second source of market linkages is information spillovers as a result of cross market hedging. The correlation of market returns creates significant hedging opportunities for investors. A news event that alters expectations of returns in a particular market changes the speculative demand in that market as well as demand for a related asset through cross market hedging. When market returns are negatively correlated, the benefits of cross market hedging will be very high. For example, the negative correlation between returns in the stock market and the money market is conducive to cross market hedging. Investors will hold stocks to hedge against negative returns in the money market while similarly, investors expecting negative stock returns will hold treasury bills to hedge against the exposure (Fleming *et al.*, 1998:117-118). The cross market hedging channel implies a negative correlation of market returns. Expected drop in returns on Treasury bills may induce investors to sell treasury bills in order to buy stocks. Given the

nature and characteristics of the financial markets-correlated returns, common information and information spillovers are expected to play an important role in their linkages (Fleming *et al.*, 1998:117-118). Thus the expectation is to observe strong linkages across the markets.

Table 6.3 presents the results of estimated models of market returns; the estimation was based on 20 lags, but only the significant lags are reported. The coefficient ρ corresponds to the lag of stock returns, γ is the coefficient of the lagged interest rate return, and the coefficient δ corresponds to the lags of exchange rate changes. The t-statistics are reported in parenthesis following the coefficients.

Table 6.3 Result of estimated multiple regression model of market returns

Model	Stock Returns	Interest rate	Exchange rate
Parameter estimates			
α_0	0.002(1.59)	-0.001(-1.74)*	0.0003(0.42)
ρ_1			0.052(1.96)*
ρ_3			-0.045(-1.67)*
ρ_5	0.082(1.74)*	-	
ρ_6	-		
ρ_8		0.049(1.74)*	
ρ_9	-	-	
ρ_{10}	-	-	0.047(1.73)*
ρ_{13}	-	0.077(2.70)**	-
ρ_{15}	-	-	-0.066(-2.39)**
ρ_{16}	-	0.070(2.44)**	-
ρ_{17}	-	-	0.049(1.78)*
ρ_{19}	-0.109(-2.24)**	0.052(1.80)*	
γ_1		0.194(4.05)***	-
γ_2		0.142(2.91)***	-
γ_4	-	-	-0.107(-2.26)**
γ_5		0.080(1.65)*	-
γ_7		-	-0.08(-1.79)*
γ_8	-0.167(-2.04)**	-	
γ_{10}	-	-	
γ_{11}	-0.163(-1.98)*	0.108(2.21)**	
γ_{13}			-0.092(1.94)*
γ_{20}			0.078(1.70)*
δ_1		-	0.301(6.44)***

δ_4		-	
δ_5	-0.20(-2.37)**	-	
δ_9	-		-
δ_{11}			-0.106(-2.18)**
δ_{12}	0.168(1.97)*	0.103(2.04)**	-
δ_{13}			0.091(1.88)*
δ_{16}			-
δ_{17}			0.087(1.80)*
R ²	0.139	0.21	0.20
ARCH LM			
Test: F	2.20(0.00)***	2.73(0.00)***	3.41(0.00)***
Observed R	42.24(0.00)***	51.24(0.00)***	62.43(0.00)***
SIC	-3.68	-4.72	-4.81
AIC	-4.18	-5.22	-5.30

* indicates significance at the 10% level

** indicates significance at the 5% level

*** indicates significance at the 1% level

According to the efficient market hypothesis, current prices should reflect all historical information and all publicly available information¹⁷. Thus, market efficiency requires a rapid adjustment of returns to all relevant information. Relevant information includes information from within the same market as well as information from the other markets. Therefore, the speed of adjustment of current returns to its own lagged returns and the lagged returns of the other markets can be interpreted as evidence of market efficiency. Here we are concerned with testing the speed of adjustment of mean returns in response to information shock. On the other hand, as discussed earlier, significant spillovers across the markets mean that there are strong linkages between the financial markets. Here the focus will be on observing the magnitude of the spillover effects as well as the direction of influence, i.e. positive or negative.

In the stock market, the response period to past information is five and 19 weeks. This means that it takes between five and 19 weeks for past information to be incorporated into current prices, which indicates a relatively slow adjustment process.

¹⁷ (Tompson (1999) and Fama (1970) in Acres (2005))

However, stock returns also respond to the lags of interest rates and exchange rates, which indicates significant spillovers from the money market and the foreign exchange market to the stock market. In the equation of stock returns, lags 5 and 12 of exchange rates are significant, thus information spillovers from the foreign exchange market are observed in the stock market.

The links between the stock market and the foreign exchange market could be explained by both common information and hedging behaviour of investors. Information related to GDP, inflation and the general direction of monetary policy affects both the stock market and foreign exchange market. On the other hand, when investors invest in foreign stock markets, exchange rate movements will affect the returns (Fang and Miller, 2002:1). Typically investors will hedge their exposure to the exchange rate risk by taking out forward cover or buying futures contracts in the stock markets. Thus, the need to hedge exposure to exchange rates will generate trading and activity in both the stock and foreign exchange markets, causing market movements to be highly correlated, albeit negatively (Fleming *et al.*, 1998). Given that the lagged exchange rates appear with both a negative and positive sign, it appears as if common information and information spillovers as a result of hedging strategies are both important.

Significant lagged influence from the money market is also found in the stock market. The lagged interest rates coefficients 8 and 11 appear with a negative sign, which implies a negative relationship between stock returns and interest rates. As mentioned earlier, the negative correlation suggests that the hedging channel is an important source of information spillovers between the stock market and the money market. Thus, information that alters expectations and returns in the money market will also alter expectations and returns in the stock market. However, spillovers in the stock market from the money market could also mean that there are common forces driving them both. Information about monetary policy and inflation affects both stock returns and interest rates. However, in this case, it appears that the hedging channel dominates, leading to a negative relationship between the two markets.

The results indicate a slow adjustment of stock returns to information spillovers from within its own market and information from the other markets; i.e. spillovers from both the money market and the foreign exchange market are delayed. In addition, only two of the lags of both interest rates and exchange rates are significant; this could mean that the magnitude of influence is reasonably weak. It would appear from the results that the stock market is not very efficient. According to Fleming *et al.*, (1998) differences in market depth can affect the degree of information spillovers. They argue that in markets that have a lower ratio of informed traders (or speculators) to uninformed traders, a large percentage shift in speculative demand will have a minor impact on prices. Therefore, the weak information spillovers in the stock markets could be an indicator of lower market depth¹⁸.

The money market indicates a rapid adjustment to past information, given that the response period to lagged interest rates is one, two, five and 11 weeks. This means that it takes about 11 weeks for information to be incorporated into current prices, which indicates a high level of market efficiency. This result is not surprising given that the South African debt markets are regarded one of the most efficient markets in the world (Faure, 2003). In addition, the liquid nature of the treasury bill market means that investors can trade relatively quickly in response to new information.

The money market also responds to information from the stock markets and the foreign exchange market. The lagged coefficients 8, 13, 16 and 19 of stock returns are significant in the equation of the money market. This indicates a high level of spillover effects to the money market originating from the stock market. Results indicate that stock returns are positively related to money market returns. This suggests the presence of common information which causes a co-movement of returns in the stock market and the money market. In general, the linkages between the stock market and the money market appear to be reasonably strong. However, spillover effects between the money market and the stock market appear to be delayed. In the stock market, the lagged response period to

¹⁸ A large percentage of the shares on the JSE is owned by institutional investors. Institutional investors include pension and provident funds, unit trusts and short and long term insurers (Faure, 2005:42).

spillovers from the money market is 12 weeks, while in the money market the lagged response of information spillovers from the stock market is 19 weeks.

A general observation is that in the relationship between the money market and the stock market, spillovers from the stock market dominate the flow of information between the two markets. This could suggest that between the stock market and the money market, the stock market has a relatively higher ratio of informed to uninformed traders.

The money market also responds to lagged information from the foreign exchange market. In addition, given that only lag 13 is significant, it appears as if the spillovers from the foreign exchange market are not that significant. Linkages between the money market and the foreign exchange market can be explained by common information, which drives the interest rate and exchange rate movements. However, for investors investing in the local and foreign debt markets, exchange rates risk is a major source of risk. Thus whenever investors are across international markets, there is always a need to hedge against exchange rate risk.

The foreign exchange market shows a rapid adjustment to last week's information. However, exchange rates also show a significant response to information 11, 13 and 16 weeks prior. This means that while the foreign exchange market is reasonably efficient, the effect of past exchange rate shocks is also highly persistent. This result is consistent with expectations. The foreign exchange market is a highly liquid market which means that speculators and traders can trade quickly in response to new information.

The foreign exchange market also responds to information from the stock market and the money market. Specifically, the results indicate a negative relationship between exchange rates and interest rates. Results also indicate that spillovers from the money market are relatively strong given that lags 4, 7, 13 and 20 of interest rates are significant in the equation of exchange rates. This suggests strong links between the money market and the foreign exchange market. Theories of exchange rates behavior such as the UIP predict a strong relationship between exchange rates and interest rates (see section 2.6). According

to the UIP, whenever interest rate differentials are not consistent with the UIP, arbitrage will take place until the UIP condition is restored. Thus speculators will trade in the debt markets driving interest rates up (down) leading to an appreciation (depreciation) in the exchange rate. Therefore, this result could be interpreted as evidence of the UIP in South Africa. In addition, the strength of the links could suggest a significant presence of foreign investors in the local debt market. On the other hand, foreign investors investing in the local money market will also attempt to hedge their exposure in the foreign exchange markets. Thus, information spillovers could also be explained by the cross market hedging strategies of investors.

The foreign exchange market also shows a significant response to information from the stock market. In addition, the foreign exchange market indicates a rapid response to information from the stock market; that is lags 1, 3, 10, 15 and 17 of stock returns are significant in the equation of exchange rates. This indicates significant linkages between the stock market and the foreign exchange market. In this case, exchange rates are positively and negatively related to stock returns. As mentioned earlier, both common information and cross market hedging strategies are an important source of links between the stock market and the foreign market. In addition, significant links between the stock market and the foreign exchange market could be an indicator of increased foreign interest in the local stock market

In sum, results suggest that the money market and the foreign exchange market are the most efficient markets. Both showed a relatively rapid adjustment to internal and external information (information spillovers). As expected, exchange rates incorporate information much faster than the stock market. This could be explained by the high level of liquidity and trading activity in the foreign exchange market.

Results of the ARCH-LM test indicate the presence of ARCH effects in each of the equations of market returns. Both F-statistic and the LM statistic from the estimated mean models are highly significant, which indicates the presence of ARCH effects in the data. In general, when ARCH effects are present, ARCH models should be used to model

volatility. To obtain estimates of market volatility, the model in 6.2.2 was estimated with a GARCH (1, 1), TARCH, and EGARCH. The next section presents the results from estimating univariate volatility models for market returns.

6.2.3 Univariate volatility models

Results of the multiple regression models of market returns found evidence of the existence of spillovers in the mean of returns. This section extends the analysis to test for spillovers in the conditional variances (i.e. volatility spillovers). However, before analysing spillovers, the market volatilities have to be generated. For each of the markets, the mean model in 6.2.2 is estimated with GARCH (1, 1), TARCH and EGARCH models. Rather than estimate the full mean model, the estimation is based on the significant lags identified earlier. The tables below present the results of this estimation.

Table 6.5 presents the results of estimating univariate volatility models for the stock market. The estimation is based on the significant lags identified in the mean model; however, only the significant lags are reported. As in the previous estimation, the coefficient ρ corresponds to the lag of stock returns, γ is the coefficient of the lagged interest rate return, and the coefficient δ corresponds to the lags of exchange rate changes. The t-statistics are reported in parenthesis following the coefficients.

Table 6.4: Presents results of estimating univariate volatility models for stock returns

Model	GARCH (1,1)	TARCH (GJR)	EGARCH
Logged all share index returns			
α_0	0.001(1.57)	0.001(1.17)	0.0008(0.76)
ρ_5	0.092(2.03)**	0.093(2.05)**	0.102(2.31)**
γ_{11}	-0.192(-3.58)***	-0.202(-3.70)***	-0.193(-3.55)***
δ_{12}	0.129(1.71)*	0.157(2.17)**	0.130(1.74)*

ω	1.42E-05(2.64)**	1.74E-05(3.21)***	-0.307(-3.30)***
α	0.047(3.71)***	-0.011(-0.793)	0.097(2.87)***
β	0.936(53.58)***	0.943(56.71)***	0.967(91.19)***
γ	-	0.089(4.36)***	-0.094(-5.45)***
R2	0.062	0.064	0.062
F Statistic	1.21(0.23)	0.94(0.52)	1.00(0.44)
Observed	24.07(0.23)	19.05(0.51)	20.22(0.44)
SIC	-4.31	-4.40	-4.42
AIC	-4.39	-4.32	-4.33

* indicates significance at the 10% level

** indicates significance at the 5% level

*** indicates significance at the 1% level

The α and β coefficients from the GARCH (1, 1) model are all highly significant. In addition, the sum of the ARCH and GARCH terms is very close to one (0.983), indicating a high degree of volatility persistence.

Consistent with empirical evidence (see Bala and Premeratne, 2004), significant leverage effects are present in the stock market. The GJR coefficient γ is 0.089; since this is positive and significant, the results suggest that good news and bad news have a differential impact on volatility. In this model, good news has an impact of α , while the impact of bad news is $(\alpha + \gamma)$. In the stock market, the impact of good news is given by -0.011, although it is not significant. The impact of bad news is 0.078, which is highly significant indicating that bad news generate higher volatility than good news. Volatility is also found to be quite persistent (0.932), although to a lesser extent. For the EGARCH model the α , β and γ coefficients are significant. The EGARCH coefficient γ is -0.094; since this is negative and highly significant, the results suggest that negative returns generate higher volatility than positive returns, all things constant.

All the models passed the autocorrelation test. The ARCH LM test indicates a failure to reject the null of no autocorrelation in all the models. This implies that all the models are properly fitted and removed autocorrelation in the data. However, only one model can be carried forward for further analysis. The ARCH LM test indicates that the F statistic from the TARCh model was the least significant. Therefore, given that the TARCh removes most of the autocorrelation in the data, the TARCh was selected.

Table 6.6 presents results of the GARCH, TARCh and EGARCH models for interest rates. As before, estimation is based on the significant lags identified in the mean model, with only the significant lags reported.

Table 6.5: Results of estimated univariate volatility models for treasury bill rates

Model	GARCH (1,1)	TARCh (GJR)	EGARCH
Logged treasury bill rate			
Parameter estimates			
α_0	-0.001(-1.58)	-0.001(-1.30)	-0.000(-1.06)
ρ_{13}	0.064(2.76)***	0.057(2.43)**	0.050(2.37)**
ρ_{19}	-	-	0.038(2.00)*
γ_1	0.265(4.38)***	0.241(4.47)***	0.276(4.00)***
γ_2	-	-	-
γ_5	-	0.077(1.75)*	-
γ_{11}	0.085(2.05)**	0.095(2.05)**	0.137(6.53)***
ω	3.75E-05(5.05)***	3.82E-05(5.31)***	-3.17(-6.72)***
α	0.075(4.92)***	0.116(4.59)***	0.463(7.72)***
β	0.783(20.58)***	0.784(21.36)***	0.649(11.95)***
γ	-	-0.090(-3.38)***	0.188(4.75)***
R2	0.14	0.14	0.14
F Statistic	0.84(0.65)	0.71(0.80)	0.78(0.73)
Observed	17.06(0.65)	14.53(0.80)	15.84(0.72)

SIC	-5.33	-5.33	-5.33
AIC	-5.43	-5.44	-5.45

* indicates significance at the 10 % Level

** indicates significance 5% Level

*** indicates significance at the 1% level

With regard to the GARCH model, the α and β coefficients are all highly significant. The model also shows some persistent ($\alpha + \beta = 0.855$) although to a lesser degree than what was observed in the stock market. In the GJR model, the coefficient γ is negative (-0.090) and highly significant indicating that news impact is asymmetric. However, while the model indicates some asymmetry, surprisingly the model predicts that the impact of bad news is a fall (i.e. γ is -0.090) rather than a rise in volatility as the theory of the TARARCH would suggest. The EGARCH model shows a γ coefficient which is positive (0.188) and significant. According to the theory of EGARCH, the coefficient γ is expected to be negative and significant, which indicates that negative shocks generate higher volatility than positive shocks. A positive sign is not consistent with theoretical expectations of the EGARCH. However, it is consistent with the findings of the GJR model above, that found insufficient evidence that bad news (negative shocks) generate higher volatility than positive shocks (good news) in the money market.

Results of the ARCH LM test failed to reject the hypothesis of no autocorrelation in all the models. This implies that all the models removed the ARCH effect in the data. However, the fact that the asymmetric coefficients γ in both the TARARCH and EGARCH models do not appear with the right sign simplifies model selection. In this case, the GARCH (1, 1) is selected for further analysis.

Table 6.7 presents the results of estimating volatility models for returns in the foreign exchange market. Similar to the previous estimations, the model is based on the significant lags identified in the mean model.

Table 6.6: Results of estimated univariate volatility models for exchange rates

Model	GARCH (1,1)	TARCH (GJR)	EGARCH
Logged exchange rates returns			
Parameter estimates			
α_0	0.000(1.82)*	0.001(2.08)**	0.001(2.66)**
ρ_3	-0.033(-1.82)*	-0.030(-1.64)*	-0.034(-1.94)*
ρ_{15}	-	-	-0.020(-1.63)*
ρ_{17}	-	-	-
γ_4	-0.0837(-2.94)***	-0.082(-2.65)**	-0.063(-2.03)**
γ_7	-	-	-0.056(1.73)*
γ_{20}	-	-	0.064(2.21)**
δ_1	0.314(6.16)***	0.322(6.31)***	0.316(6.30)***
ω	4.28E-06(2.62)**	3.63E-06(2.31)**	-0.59(-4.34)***
α	0.247(6.89)***	0.274(6.61)***	0.37(7.12)***
β	0.775(27.28)***	0.790(25.97)***	0.964(70.98)***
γ	-	-0.083(-1.51)	0.062(2.17)**
R2	0.10	0.10	0.10
F Statistic	0.90(0.58)	0.87(0.61)	0.84(0.65)
Observed	18.12(0.57)	25.64(0.60)	17.09(0.64)
SIC	-5.57	-5.56	-5.58
AIC	-5.71	-5.71	-5.72

- * indicates significance at the 10%
** indicates significance at the 5% level
*** indicates significance at the 1% level

In general, all the, α , β and γ coefficients from all the models are significant. The GARCH (1, 1) model reports a high level of persistence (sum of α and $\beta = 1.02$). This

indicates that the model is explosive; that is, shocks to the system will not die off, but will tend to increase over time.

In the GJR model, the coefficient γ is negative (-0.083) and insignificant, which indicates that there are no leverage effects. Thus the model finds no evidence that bad news generates higher volatility than good news. The model is also explosive, with α and β coefficients being more than one (1.06). In the EGARCH model, the coefficient γ is 0.062, and since this value is positive and significant the model finds no evidence that negative shocks generate higher volatility than positive shocks. However, the model shows significant volatility persistence. In addition, unlike the other models, the effect is not explosive. The EGARCH coefficient is 0.964 and it is significant. On the other hand, all the models also show a higher α coefficient which measures the impact of short term shocks. A higher value implies that in the foreign exchange market, the impact of short term shocks is higher and the shock tends to linger around for a longer period (Bala and Premaratne, 2004:17).

Yet again all the models passed the diagnostic checks (autocorrelation tests), which means that all the models removed the autocorrelation in the data. However, given the explosive nature of both the GARCH and TARARCH models, the EGARCH model is selected as the best model. The conditional variances from each of the selected models are used as inputs into a model for volatility spillovers. The results of this estimation are reported in the next section.

6.2.4 Trend analysis

The following sections analyses the trend and interactions of market volatilities. An examination of Table 6.7 shows that volatility in the stock market and money market is decreasing. The decreasing volatility trend in these markets could be attributed to a more stable monetary policy that is stability orientated. The declining volatility trend in the markets is consistent with the long run movements of the market as discussed in chapter four. With the exception of the emerging market crisis in 1985, 1997 and 1998, volatility

in the stock market and the money market appears to be in decline. On the other hand, volatility in the foreign exchange market appears to be increasing over time. An increasing trend in volatility in the foreign exchange market is generally associated with a floating exchange rate regime (Frommel and Menkoff, 2003).

Table 6.7: Results of volatility trend analysis

Market	Stock Returns	Interest rate	Foreign exchange rate
Parameters estimates			
α_0	0.0008(23.81)***	0.0003(19.59)***	8.93E-05(2.98)***
φ	-3.59E-07(-3.71)***	-1.23E-07(-2.58)**	6.51E-07(7.07)***
R^2	0.02	0.01	0.08

* indicates significance at the 10% level
 ** indicates significance at the 5% level
 *** indicates significance at the 1% level

6.3 MODELLING VOLATILITY SPILLOVERS: MULTIVARIATE VAR OF CONDITIONAL VARIANCES

To examine spillovers in the conditional variances, a multivariate VAR model of conditional variances is estimated. As can be recalled, in the stock markets the TARCH model was selected, while GARCH and EGARCH were selected as the best models in the case of the interest rate and exchange rates. The model of volatility spillovers uses the conditional variances series from these models as endogenous variables in the VAR.

Table 6.8 below presents the results of this estimation. While the estimation is based on 20 lags, only the significant lags are reported. The coefficient ψ corresponds to the lagged conditional variances of stock returns, the coefficient λ is for the lagged conditional variances of interest rates and the coefficient θ represents the lagged conditional variances of exchange rates.

Table 6.8: Results of estimated multivariate VAR model of market volatilities

Market Model	Stock Returns TARCH	Interest rate GARCH	Foreign exchange rate EGARCH
Parameter estimates			
α_0	2.33E-05(1.74)*	3.24E-05(2.88)***	2.33E-05(0.94)
Ψ_1	1.014(20.35)***	-	-
Ψ_2	-0.118(-1.67)*	-	-
Ψ_7	-	-	-
Ψ_9	-	-	-
Ψ_{11}	-	-	0.234(2.644)**
Ψ_{12}	-	-	-0.196(-2.24)**
Ψ_{13}	-	-	0.18(2.19)**
Ψ_{14}	0.1359(2.44)**	-	-
Ψ_{15}	-0.137(-2.10)**	-	-
Ψ_{18}	-	-	-0.195(-2.26)**
Ψ_{19}	-	-	0.233(2.68)**
λ_1	-	0.804(16.08)***	-
λ_2	0.156(2.03)**	0.192(2.96)***	-
λ_3	-0.126(-1.62)*	-	0.423(4.13)***
λ_4	-	-	-0.547(-5.23)***
λ_5	-	-	0.448(4.15)***
λ_6	-	-	-0.451(-4.10)***
λ_8	0.161(1.88)*	-	-
λ_9	-0.214(-2.51)**	-	-
λ_{10}	0.209(2.42)**	-	-
λ_{11}	0.413(4.75)***	0.155(2.12)**	-
λ_{12}	-0.42(-4.78)***	-0.189(2.52)**	-
λ_{13}	0.305(3.35)***	-	-
λ_{15}	-0.175(-1.90)*	-	-
λ_{18}	-	-	0.386(3.15)***

λ_{19}	-	-	-0.508(-4.09)***
θ_1	-0.065(-1.82)*	-	1.02(21.69)***
θ_2	-	-	-
θ_3	-	-	-
θ_4	-	-	-0.227(-3.46)***
θ_5	-0.105(-2.05)**	-	-
θ_8	0.141(2.74)**	-	-
θ_9	-0.100(-1.93)*	-	-
θ_{10}	-	-	-
θ_{11}	-	-	-
θ_{12}	0.101(1.91)*	-	-
θ_{13}	-	-	-
R^2	0.94	0.78	0.83

* indicates significance at the 10% level

** indicates significance at the 5% level

*** indicates significance at the 1% level

In assessing interactions of market volatilities, it is useful to distinguish between volatility shocks from within the same market and volatility that is transmitted across the markets. A news event that alters expectations of returns within a single market will generate trading and volatility within that market. As mentioned earlier, common information and information spillovers provide a channel for the transmission of volatility shocks across the financial markets. This section tests for volatility transmission within the same market and cross market volatility transmission (Hurditt, 2004: 2).

Volatility shocks emanating from within the stock market are also present in the stock market. Current volatility responds to volatility 1, 2, 14 and 15 weeks prior, which means that volatility of stock returns is also affected by historical volatility in the stock market. Conversely, significant cross market volatility spillovers are found in the stock market. In particular, interest rate volatility appears to be the main source of volatility spillovers in this market. Nine lags of the conditional variance of interest rates are significant in the

equation of stock prices, which include lags 2, 3, 8, 9, 10, 11, 12, 13 and 15. In the initial period, interest rate volatility induces a positive response which becomes significantly negative after the first lag. The negative and positive sign on the coefficients of the lagged interest rate volatility means that interest rate volatility has both a positive and a negative impact on volatility in the stock returns. With regard to the volatility relationship, the common information implies a positive volatility relationship while the hedging channels predict a negative volatility relationship. Common information that simultaneously alters expectations of market returns generates trading and volatility in all the markets. Thus in this case, monetary policy shocks will lead to an increase in volatility in both the stock market and the money market. On the other hand, given an increase in volatility in a particular market, speculative investors will take a position in one market to hedge against their exposure in the other market, generating trading and volatility in both markets. However, if the hedge is effective, it should decrease volatility of the hedged asset returns.

Significant volatility spillovers from the foreign exchange market are also found in the stock market; lags 1, 5, 8, 9 and 12 are significant, which indicates significant volatility spillovers, although to a lesser extent than spillovers from the money market. Volatilities are predominantly negatively correlated, and with the exception of lags 8 and 12 all lags appear with a negative sign. This means that the impact of exchange rate volatility is a decline in volatility of stock returns, and common information is not that significant in explaining volatility spillovers between the stock market and the foreign exchange markets. A negative volatility relationship implies that volatility in the foreign exchange leads to a reduction in volatility of stock returns. This is possible if investors hedge the exposure to exchange rate risk which reduces the overall volatility of expected stock returns.

Significant own market volatility shocks are found in the money market. Interest rate volatility responds to lags 1, 2, 11 and 12 of its own shocks. Surprisingly, none of the lags of stock returns and exchange rates is significant in the equation of interest rates, implying that there are no volatility spillovers in the money market. This result suggests

an asymmetric volatility response of the other markets to interest rates volatility; while interest rate volatility is a significant driver of other markets' volatility, the other two markets have no impact on interest rate volatility. This suggests that interest rate volatility is largely independent of volatility in the stock market and the foreign exchange market. The principal driver of volatility of treasury bill rates is monetary policy and inflation. Treasury bill rates generally move in tandem with the repo rate and the other money market rates. However, treasury bill rates are also driven by external factors such as supply and demand forces. Thus, some correlation between volatility in the money market and the other market should be observed. However, the results suggest otherwise, implying that monetary policy is possibly the single most important driver of interest rate volatility in South Africa.

As in the case of the stock market, significant own market volatility shocks are found in the foreign exchange market. In addition, exchange rates display a strong response to volatility 1 and 4 weeks prior. This suggests that the most recent volatility shocks have a significant impact on current and future volatility of exchange rates.

Significant cross market volatility spillovers are observed in the foreign exchange market. Exchange rate volatility displays a strong response to both interest rates and stock market volatilities. However, the strongest spillover effect originates from the money market. The lagged coefficients 3, 4, 5, 6, 18, and 19 of interest rates are significant in the equation of foreign exchange rates. It appears that the impact of interest rate volatility in the foreign exchange market is both positive and negative. The results are as expected, given the presence of common information and information spillovers between the money market and the foreign exchange market.

Significant volatility spillovers from the stock market are also found in the foreign exchange market. However, unlike the money market, the spillover effects appear to be delayed; i.e. lags 11, 12, 13, 18, 19 are significant. In general, the results suggest that volatility in the other market fundamentals such as interest rates and stock prices are significant drivers of exchange rate volatility. This result could be interpreted as evidence

against theories of a “disconnect” between exchange rate volatility and volatility in the underlying market fundamentals.

The VAR analysis is useful to test for the presence of spillovers across the markets. However, the major problem with the VAR is the difficulty in interpreting the estimates. Also, the VAR estimates themselves tell us very little about the transmission of shocks across the markets or the period of time it takes for shocks to work through the system.

To examine dynamic links between the markets and the transmission of volatility shocks, impulse responses and variance decompositions are generated from the VAR. Impulse responses analysis is useful in that it shows how market volatilities respond to volatility shocks from the other markets. Variance decomposition shows the relative importance of shocks originating from one financial market to another market. This analysis can also be used to identify the leading market, which is defined as the market that explains a large percentage of the error variance of the other markets while its own forecast error variance is not explained by innovations in other markets.

6.3.1 Results of impulse responses and variance decomposition

Figure 6.4 and 6.5 in the Appendix report the impulse responses for exchange rates, interest rates and stock prices. Table 6.4 in the appendix presents the variance decomposition.

6.3.1.1 Exchange rates

Figure 6.4 and 6.5 in the Appendix show the response of exchange rate volatility to a volatility shock emanating from the other two markets.

Impulse Responses

Figure 6.4 presents the response of the variance of exchange rates to a one standard deviation innovation in each of the markets. As one would expect, exchange rate volatility responds highly to innovations in its own market. This response peaks in the 2nd period and somewhat persists over time. Results indicate a significant positive response of exchange rate to interest rates volatility. The response rises in the 3rd period and peaks in the 6th period. Thus, there is no evidence of volatility trade off between exchange rates and interest rates. The response of exchange rates to innovations in the stock market is delayed. In the first period, exchange rates do not respond to stock market volatility; however, as from the 4th period, exchange rates display a negative response to stock market volatility.

Variance Decomposition

In the first three periods, almost all the variation in the variance of exchange rates is explained by its own innovations. However, in the 4th period, 97% of the variation in exchange rate volatility is explained by variation in its own shocks, while interest rate volatility explains 2.59% of the variation. The contribution of interest rate volatility to volatility of exchange rates increases to 7% and 10.7% in the 6th and 10th periods. Volatility of stock returns explains less than 1% of exchange rate volatility. Relative to stock market volatility, interest rate volatility appears to be the main driver of exchange rate volatility. While the relative influence of interest rate volatility appears large (10.7%), it is evidence that there are other forces driving exchange rate volatility which are not accounted for by both interest rates and stock market volatilities. Studies that examined exchange rates behaviour identified the following factors that may drive exchange rate volatility in developing countries: sovereign risk, economic and political uncertainty, and what is often referred to as credibility factors, which can cause exchange rate movements to deviate from the path dictated by economic fundamentals (Belke *et al.*, 2003:1-4).

6.3.1.2 Interest rates

Impulse Responses

Figure 6.4 displays the response of the variance of the interest rate to one standard deviation innovation in each of the markets. As expected, interest rates respond strongly to innovations in their own market. Interest rates volatility displays a small response to both exchange rate and stock market volatility shocks. In addition, the direction of response is not clear since responses change signs frequently.

Variance Decomposition

In the first period, almost all the variation in the variance of interest rates is accounted for by its own shocks. Up to the 10th period, 99.58% of the variation in interest rate volatility is accounted for by its own shocks. Both exchange rate and stock market volatility explain less than 1% of the variation in the variance of interest rate volatility. This result is consistent with earlier results that found no volatility spillovers to the money market. It appears as if shocks to interest rate are emanating from within the money market. As mentioned earlier, treasury bill rates are directly related to repo rate and other money market rates. Thus results could be an indicator of the strength of these internal forces driving interest rate volatility.

6.3.1.3 Stock returns

Impulse Responses

Figure 6.4 and 6.5 shows the response of variance of stock returns to a one standard deviation innovation in the other markets. The stock market shows a significant response to innovations in both interest rates and exchange rates volatility. Volatility of stock returns is positively related to interest rates volatility. The response peaked in the 3rd period and tends to persist over time. Stock market volatility displays a significantly negative response to volatility in the foreign exchange market. However, this response becomes positive in the 8th period and persists over time.

Variance decomposition

In the first period, 89% of the variation in the variance of stock returns is explained by its own shocks, while interest rate shocks explain 10.75%. The relative importance of interest rates volatility in influencing stock market volatility declines to 8% in the last period. This result is in line with both theoretical expectations and empirical evidence. Given that interest rates represent a significant input in the valuation of stock prices, any variation in interest rates should be reflected in stock returns. The effect of interest rate shocks on returns is also highly persistent; even after 10 periods, it remains at 8.77%. While impact of interest rate volatility in the stock market is relatively high (8.77%), it is also evident that there are other forces driving the volatility of stock returns that explain the 90% which is unaccounted for by both interest rates and exchange rates. These might include volatility in company earnings and supply and demand forces within the stock market as well as other external forces.

Less than 1% of the variation in the volatility of stock returns is explained by variation in exchange rates volatility. Even in the last period, exchange rate volatility explains less than 1% of volatility of stock returns. A low correlation between volatilities could be a reflection of low percentage of local stocks owned by foreign investors.

In summary, interest rate volatility explains 10.7% of exchange rate volatility and 8.77% of volatility of stock returns. The combined impact of both exchange rate and stock returns volatility on the money market is less than 1%. On the other hand, exchange rate volatility accounts for less than 1% of both interest rate and stock returns volatility. The combined impact of interest rate and stock returns on volatility of exchange rates is 11.37%. Stock price volatility explains less than 1% of both exchange rate and interest rates volatility. The combined influence of both exchange rates and interest rates on stock market volatility is 9.40%.

Finally, the results suggest that the foreign exchange market is the most endogenous market, with 11.37% of its variance explained by shocks in the other markets. The money

market appears to be the leading market, given that less than 1% of its variance is explained by shocks emanating from the other markets.

6.4 CONCLUSION

This chapter presents and discusses the empirical results and findings of this study. The first part of the chapter focused on examining volatility trends and the unique features of volatilities such as persistence and asymmetry. The dominant trend in the market is of a decrease in volatilities. However, volatility in the foreign exchange market displayed an increasing trend. In addition, volatilities were also found to be highly persistent.

The second part of the chapter focused on examining information and volatility spillovers in the markets. Significant spillovers in the mean of returns were found. As mentioned in chapter five, informational spillovers could give rise to cross correlations of market volatility. Hence the study also tested for cross correlation of market volatilities and associated spillover effects. These results were also discussed in the last part of the chapter. Results of this estimation indicated the presence of some spillovers, most notably in the stock market and the foreign exchange market. Volatility spillovers were not found in the money market. On the other hand, the money market was found to be the leading market (exogenous market), while the foreign exchange market was identified as the most endogenous market.

The next chapter summarises the main results and findings of the study as well as making policy recommendations based on the findings.

CHAPTER SEVEN

SUMMARY OF FINDINGS AND POLICY RECOMMENDATION

7.0 SUMMARY OF MAIN FINDINGS

The study examined financial instability in South African, focusing on asset price volatility as a manifestation of instability. While volatility is a natural feature of the markets, volatility spillovers can propagate volatility shocks, increasing the risk of a wide spread instability. Common information shocks and information spillovers are the main source of volatility linkages. The former shocks occur when information related to economic fundamentals simultaneously alters market expectations, generating trading and volatility across the markets, and thus leading to volatility co-movement. Volatility spillovers are also related to the hedging strategies of investors and speculators. For investors investing in the financial markets, a news event that alters expectations of returns in a single market generates trading and volatility in that market and a related market through cross market hedging.

To examine information spillovers, a simple multiple regression model of lagged market returns was estimated. In this model, significant information spillovers were interpreted as evidence of strong market linkages. However, the response of market returns to lagged information has significant implications for market efficiency and thus was of interest in this study. A market is efficient if it incorporates past information relatively faster than the other markets.

Given that market returns exhibit features of non-normality, the ARCH family of models was employed to estimate market volatility. To examine the nature of market volatilities, volatility trends were analysed and compared to recent trends in market volatilities as discussed in Chapter Four. An analysis of volatility spillovers is central to this study, thus a major section of the analysis focused on analysing volatility spillovers. To this end, a multivariate VAR model of the conditional variances was estimated. This model was

useful in that it not only provided a framework to examine market interactions, it also allowed us to examine the short run dynamics of market volatilities such as transmission of shocks across the markets. Understanding the transmission of shocks across the market is crucial to an understanding of contagion and systemic risk, which are all key ingredients in the development and spreading of instability.

The results of the mean returns indicate some linkages between the markets. The links between the stock market and the money market were found to be particularly strong. In addition, in the money market, information originating from the stock market appears to dominate information from the foreign exchange market. At the same time, information spillovers from the stock market also dominate the flow of information to the money market. These results suggest that there are strong linkages between the stock market and the money market. The strong links between the stock market and the money market means that investors investing in both the markets must consider the impact of information spillovers when making their investment decision.

The foreign exchange market displayed strong links to both the stock market and the money market. However, in the mean returns, information spillover from the stock market was greater than information from the money market. A strong link between the stock market and the foreign exchange market implies that exchange rate movements signal information about the future movements of stock returns. In addition, this means that stock market movements will be reflected in exchange rate movements, increasing the sensitivity of the exchange rate to portfolio investments flows. This could have a potentially destabilising effect on the currency if a reversal of portfolio flows occurs.

In terms of market efficiency, the money market and the foreign exchange market appear to be the most efficient markets; i.e. the market that incorporates information faster than the other markets. In the stock market, the response of stock returns to past information was delayed, thus it was the most inefficient market of the three.

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. Empirical evidence often found volatilities to be highly persistent in financial markets (see Bala and Premeratne, 2004:18). Consistent with earlier empirical studies, this study found market volatilities exhibiting high level of persistence. In particular, the foreign exchange volatility exhibited the highest persistence, followed by the stock market and money market. Moreover, in the stock market there is evidence of asymmetric volatility response. It appears as if bad news (negative returns) gives rise to higher volatility than good news (positive returns).

From a financial stability point of view, policy makers are concerned about how volatilities in the markets are transmitted across the markets, which may cause systemic risk and financial instability at the extreme. The results indicate significant volatility spillovers in the markets.

In the stock market, significant volatility spillovers from the money market were found. However, the direction of influence is not clear, given that sign changes from positive to negative. This could mean that common information causes a co-movement of volatility while perhaps the hedging channel causes volatilities to be negatively related. Spillovers from the foreign exchange market were also found in the stock markets, but to a lesser extent than the spillover effect from the money market. Interest rate volatility appears to be the main source of volatility spillovers in the stock market. This result is also confirmed by the impulse response and the variance decomposition analyses, which revealed that interest rates shocks are a major source of volatility shocks in the stock market.

Significant volatility spillovers from both the money market and the stock market were found in the foreign exchange market. However, the strongest spillover effects are those from the money market. This result is consistent with the impulse responses and the variance decomposition analyses which showed that interest rate shocks are the main source of volatility shocks in the foreign exchange market.

There were no volatility spillovers from the stock market and the foreign exchange market to the money market. This means that interest rate volatility is independent of volatility in the financial markets. This result was also confirmed by the impulse response and variance decomposition that showed that both stock market and exchange rate volatility had an insignificant impact on interest rates volatility. This suggests that there may be other forces driving interest rate volatility. In South Africa, this may be driven primarily by monetary policy shocks and inflation.

In terms of transmission of volatility shocks across the financial system, volatility shocks from the money market appear to be the dominant source of volatility shocks in the financial markets. This implies that shocks originating in the money market are transmitted to both the stock market and the foreign exchange market. In terms of lead lag relationship, the money market is identified as the leading market, while the foreign exchange market is identified as the lagging market. In addition, while significant spillovers were observed from the leading market to the other market, there were no spillovers from the lagging markets to the leading market.

A general observation is that cross market volatility shocks and transmission across the markets do not account for most of the volatility shocks in the market. This is because the leading market (which is expected to account for most of the volatility spillovers) only accounts for about 11.37% and 8.77% of volatility shocks in the other markets. This suggests that there may be external forces driving market volatilities such as perceptions of market risk, sovereign risk, and political uncertainty, all of which may have a significant impact on market volatility.

In conclusion, the findings of this study highlight two important policy implications. Firstly, that interest rate volatility was the main source of volatility spillovers and shocks in the markets. Since one of the main drivers of volatility in the money market is monetary policy shocks, it highlights the important role of monetary policy in order to ensure the stability of the financial system. This is a source of fierce debate and so far

consensus has not been reached about what this role should be (Mishkin, 2001). However, what is evident from this study is the need for a stable monetary policy environment to ensure that monetary policy shocks are not an additional source of volatility shocks in the market. Secondly, the fact that volatility spillovers across the markets only account for a relatively small proportion of the volatilities in the markets stresses the need to look beyond the markets for possible causes of volatility and possible instability. Some specific suggestions to address these issues are presented next.

7.1 POLICY PROPOSALS

The first policy proposal addresses the issue of the role of monetary policy in the financial market. With regard to the appropriate role of monetary policy in the market, the focus should be on two main issues: (1) monetary policy as an additional source of instability in the market - through the impact of interest rate shocks on volatility in the other markets, and (2) the stabilisation role of monetary policy, in response to asset price bubbles. This will be returned to further below.

In addition, as mentioned earlier, asset price volatility in itself is not that disruptive, the focus of policy should be on identifying the conditions under which volatility can turn into instability rather than directly controlling the level of asset prices. Section, 2.2.3 highlighted some of the factors that can exacerbate volatility, increasing the risk of instability. Therefore, efforts to prevent instability should also focus on addressing some of these problems. This includes measures to discourage excessive risk taking and leverage trading. These are also discussed below.

7.1.1 Monetary policy

The precise stabilisation role of monetary policy in response to asset price bubbles is a source of fierce debate. For example, Mishkin (2001) points out that monetary authorities are often reluctant to target asset prices because of the practical problems that doing so

would present, i.e. the difficulty in identifying asset price bubbles if and when they arise (Mishkin, 2001). While monetary policy should not target asset prices, it is important to monitor asset prices to prevent the build up of imbalances that may destabilise the markets (see Section 2.5). Therefore, given these practical problems, the focus should be on making monetary policy stable and predictable. Indeed, the results of this study highlight the need for stability in monetary policy-interest rates. Making monetary policy predictable will ensure that interest rate shocks are not an additional source of volatility shocks in the markets. This will also discourage speculation in the markets, since investors will be informed about the direction of monetary policy.

The results also indicate that there are forces beyond the control of monetary policy that might be driving market volatilities. For example, credibility factors such as sovereign and market risks, and political uncertainty are sources of market volatility (and instability). Since the role of these factors is beyond the scope of the current study, more studies are called for to explore the relative importance of these factors in the financial system in South Africa. However, it is worth mentioning that given the potentially disruptive effects of sudden changes in sentiment following an increase in risks or a change in investors' perceptions of risks (Belke *et al.*, 2003), monitoring and minimising the country's risks (political, market and sovereign) must be a continuous exercise. An important element in achieving this would be to ensure a stable political environment as well as independence and credible central bank and monetary policy officials to ensure public (investors') confidence.

7.1.2 Regulation of institutions and incentives to prevent excessive risk taking

While regulation is important, there is a need for an appropriate balance between regulation and allowing markets to operate freely (Crocket, 1997). Regulation should be strict enough to prevent excessive risk taking while allowing markets to operate free of unnecessary interventions. Self regulation is one of the pillars of the stock markets and it is argued that self regulation is more effective since market practitioners are in a better

position to assess market risk than officials (Crockett, 1997). While there is a strong case for self regulation in organised markets like the stock market and the bond market, the argument for self regulation in the banking market is less convincing. This is because banks are naturally vulnerable to excessive risk taking, especially that which is associated with a lending boom. This strengthens the case of strict regulation of the banking market.

Within the asset markets, there is a need to address imbalances that may lead to excessive risk taking. This requires a great deal of innovation among the participants in the market to design policies and strategies to deal with these problems. However, there needs to be some cooperation between policy makers and market participants to ensure that proper policies are put in place.

While the study was limited to the three markets, the analysis can be extended to other markets such as the bond market or the derivative markets. Another issue worth exploring is the international transmission of volatility shocks, which would entail a cross country study of volatility transmission.

Appendices

Table 6.1: Correlogram of stock returns

Date: 01/05/07 Time: 09:19 Sample: 1/07/1996 7/30/2006 Included observations: 552						
Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob	
		1	0.990	0.990	544.24	0.000
		2	0.981	-0.005	1078.8	0.000
		3	0.970	-0.033	1603.1	0.000
		4	0.959	-0.033	2116.8	0.000
		5	0.949	0.012	2620.2	0.000
		6	0.938	-0.021	3113.0	0.000
		7	0.928	0.024	3596.1	0.000
		8	0.918	0.031	4070.1	0.000
		9	0.908	-0.053	4534.3	0.000
		10	0.897	-0.010	4988.6	0.000
		11	0.887	0.015	5433.6	0.000
		12	0.876	-0.076	5868.0	0.000
		13	0.865	0.008	6292.1	0.000
		14	0.853	0.002	6706.1	0.000
		15	0.842	-0.017	7109.9	0.000
		16	0.831	0.014	7504.0	0.000
		17	0.820	0.010	7888.8	0.000
		18	0.810	0.016	8264.7	0.000
		19	0.800	-0.018	8631.8	0.000
		20	0.791	0.051	8991.0	0.000
		21	0.782	0.048	9343.5	0.000
		22	0.774	0.005	9689.4	0.000
		23	0.766	0.000	10029.	0.000
		24	0.758	-0.016	10362.	0.000
		25	0.750	0.003	10688.	0.000
		26	0.742	-0.023	11008.	0.000
		27	0.733	-0.024	11322.	0.000
		28	0.725	0.034	11629.	0.000
		29	0.717	0.003	11930.	0.000
		30	0.710	0.014	12225.	0.000
		31	0.703	0.016	12515.	0.000
		32	0.696	-0.026	12800.	0.000
		33	0.689	-0.008	13080.	0.000
		34	0.682	0.006	13354.	0.000
		35	0.675	0.011	13624.	0.000
		36	0.668	0.003	13889.	0.000

Table 6.2: Correlogram of interest rate

Date: 01/05/07 Time: 09:20 Sample: 1/07/1996 7/30/2006 Included observations: 552						
Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob	
		1	0.996	0.996	551.10	0.000
		2	0.992	-0.146	1098.2	0.000
		3	0.986	-0.144	1640.0	0.000
		4	0.980	-0.026	2176.2	0.000
		5	0.974	-0.017	2706.3	0.000
		6	0.967	-0.046	3230.0	0.000
		7	0.960	-0.033	3746.8	0.000
		8	0.952	-0.007	4256.7	0.000
		9	0.944	-0.079	4758.9	0.000
		10	0.936	-0.016	5253.2	0.000
		11	0.928	0.003	5739.6	0.000
		12	0.919	-0.044	6217.5	0.000
		13	0.910	-0.006	6687.0	0.000
		14	0.900	-0.024	7147.8	0.000
		15	0.891	-0.008	7599.9	0.000
		16	0.881	-0.003	8043.1	0.000
		17	0.872	-0.033	8477.3	0.000
		18	0.862	0.023	8902.5	0.000
		19	0.852	-0.028	9318.8	0.000
		20	0.842	0.015	9726.1	0.000
		21	0.832	0.013	10125.	0.000
		22	0.822	0.014	10515.	0.000
		23	0.812	-0.003	10896.	0.000
		24	0.803	0.017	11270.	0.000
		25	0.793	0.005	11635.	0.000
		26	0.784	0.027	11993.	0.000
		27	0.775	-0.004	12343.	0.000
		28	0.766	-0.008	12685.	0.000
		29	0.757	-0.020	13021.	0.000
		30	0.748	-0.010	13349.	0.000
		31	0.739	-0.029	13669.	0.000
		32	0.730	-0.011	13982.	0.000
		33	0.720	-0.009	14288.	0.000
		34	0.711	0.015	14587.	0.000
		35	0.702	0.042	14878.	0.000
		36	0.694	0.007	15164.	0.000

Table 6.3: Correlogram of exchange rates

Date: 01/05/07 Time: 09:22 Sample: 1/07/1996 7/30/2006 Included observations: 552						
Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob	
		1	0.993	0.993	547.58	0.000
		2	0.985	-0.101	1087.4	0.000
		3	0.977	-0.028	1618.9	0.000
		4	0.968	-0.005	2142.1	0.000
		5	0.960	-0.011	2656.9	0.000
		6	0.951	-0.008	3163.3	0.000
		7	0.942	0.016	3661.7	0.000
		8	0.935	0.059	4152.9	0.000
		9	0.927	-0.050	4636.7	0.000
		10	0.919	0.011	5113.1	0.000
		11	0.911	-0.006	5582.2	0.000
		12	0.903	0.019	6044.4	0.000
		13	0.896	0.007	6499.9	0.000
		14	0.889	-0.003	6948.9	0.000
		15	0.882	0.021	7391.5	0.000
		16	0.875	0.020	7828.4	0.000
		17	0.869	0.016	8259.9	0.000
		18	0.862	-0.019	8685.8	0.000
		19	0.856	0.002	9106.2	0.000
		20	0.849	-0.022	9520.9	0.000
		21	0.843	0.011	9930.1	0.000
		22	0.836	0.003	10334.	0.000
		23	0.830	-0.014	10732.	0.000
		24	0.823	-0.007	11125.	0.000
		25	0.817	0.007	11512.	0.000
		26	0.810	-0.004	11893.	0.000
		27	0.804	-0.001	12270.	0.000
		28	0.797	0.007	12641.	0.000
		29	0.791	0.018	13007.	0.000
		30	0.785	0.002	13368.	0.000
		31	0.780	0.001	13725.	0.000
		32	0.773	-0.031	14076.	0.000
		33	0.767	0.009	14423.	0.000
		34	0.761	-0.029	14765.	0.000
		35	0.754	-0.045	15101.	0.000
		36	0.746	-0.049	15431.	0.000

Table 6.4: Variance Decomposition

Variance Decomposition

Variance Decomposition of exchange rate volatility:				
Period	S.E.	exchange rat	interest rate	stock returns
1	0.000133	100.0000	0.000000	0.000000
2	0.000190	99.97640	0.023332	0.000269
3	0.000230	99.95482	0.044884	0.000295
4	0.000269	97.36513	2.592113	0.042755
5	0.000293	96.56163	3.371984	0.066383
6	0.000313	92.75614	7.071386	0.172477
7	0.000326	90.70080	9.100102	0.199095
8	0.000332	89.83664	9.816831	0.346527
9	0.000337	89.01231	10.45011	0.537588
10	0.000340	88.61611	10.70604	0.677852
Variance Decomposition of interest rate volatility:				
Period	S.E.	exchange rat	interest rate	stock returns
1	8.55E-05	0.004178	99.99582	0.000000
2	0.000110	0.124149	99.87335	0.002498
3	0.000131	0.142890	99.85528	0.001828
4	0.000147	0.116014	99.76882	0.115163
5	0.000156	0.152316	99.69339	0.154298
6	0.000163	0.142080	99.69739	0.160533
7	0.000166	0.171858	99.65891	0.169228
8	0.000169	0.226814	99.60620	0.166989
9	0.000170	0.232494	99.59913	0.168373
10	0.000171	0.242305	99.58923	0.168463
Variance Decomposition of stock price volatility:				
Period	S.E.	exchange rat	interest rate	stock returns
1	0.000102	0.001803	10.75455	89.24364
2	0.000144	0.328110	9.116824	90.55507
3	0.000172	0.546908	10.08464	89.36845
4	0.000191	0.638989	9.923595	89.43742
5	0.000205	0.566243	9.586031	89.84773
6	0.000218	0.503383	9.091656	90.40496
7	0.000229	0.499602	8.932374	90.56802
8	0.000240	0.589241	8.716064	90.69470
9	0.000249	0.590144	9.020494	90.38936
10	0.000255	0.635418	8.770738	90.59384
Cholesky Ordering: EGARCHUSDZAR GARCHTBT3 TARCH				

Figure 6.1: Exchange rate volatility

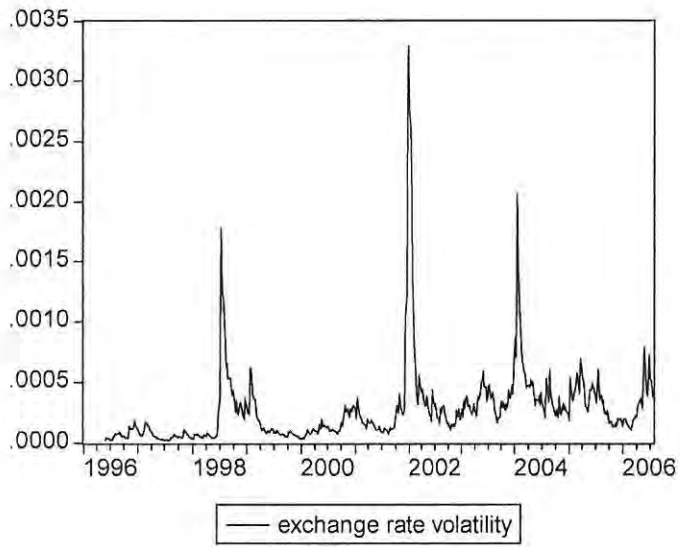


Figure 6.2: Interest rate volatility

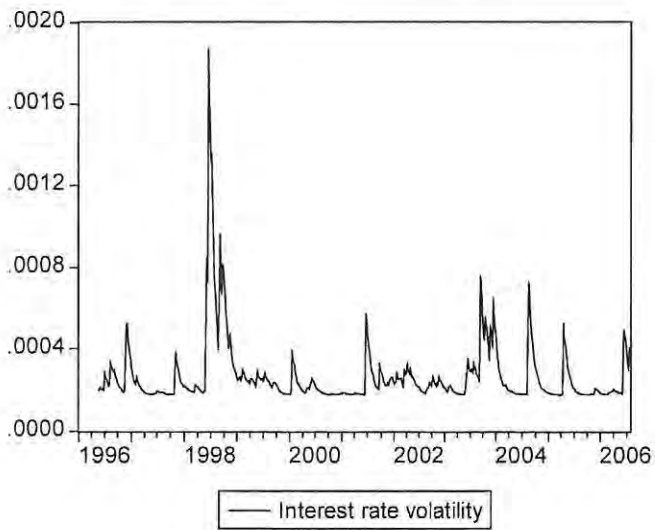


Figure 6.3: Volatility of stock returns

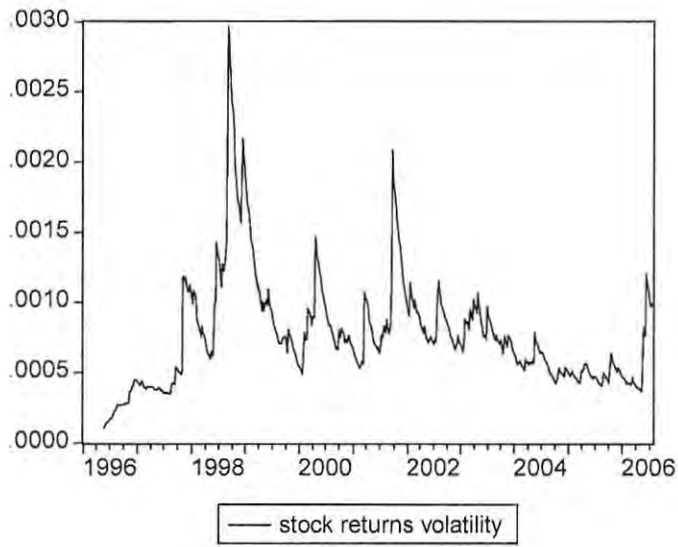


Figure 6.4: Impulse Responses

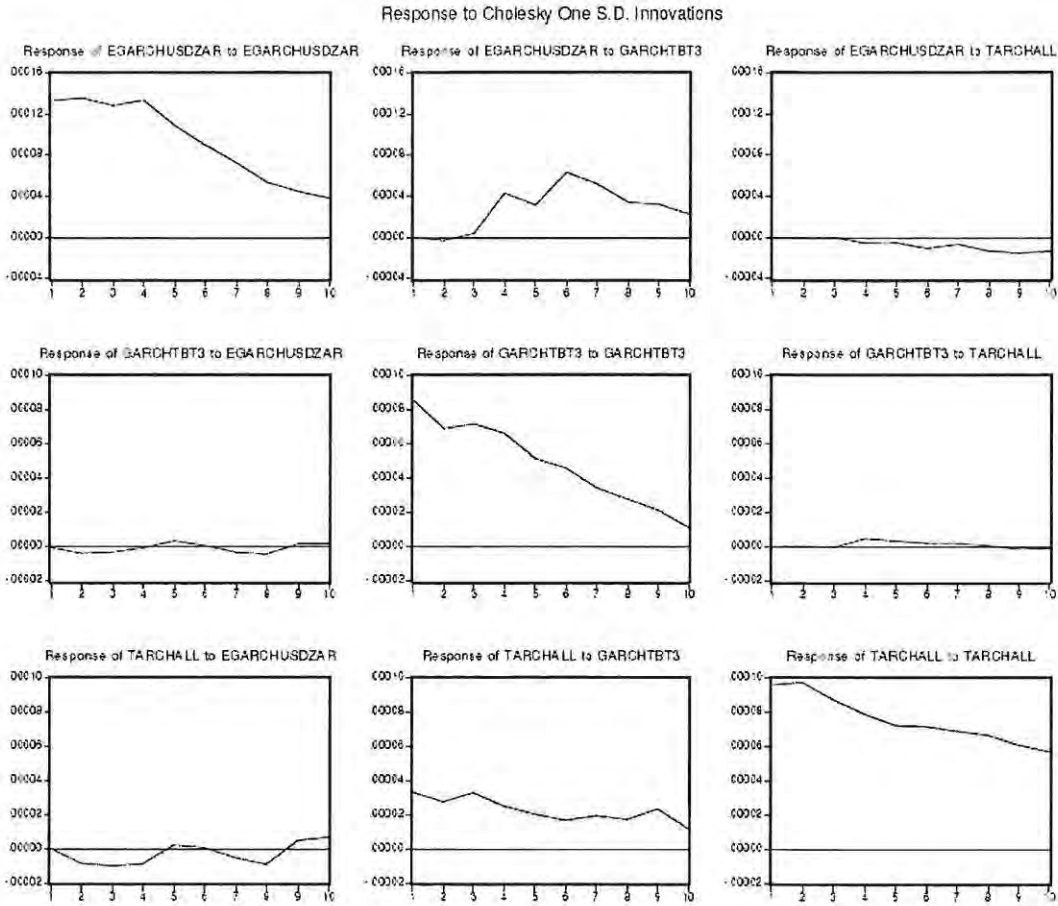
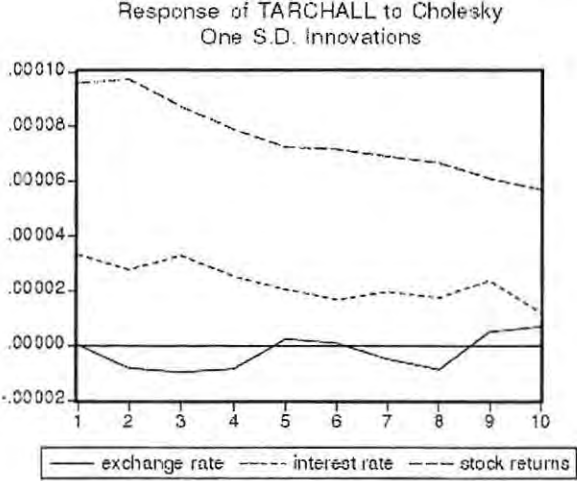
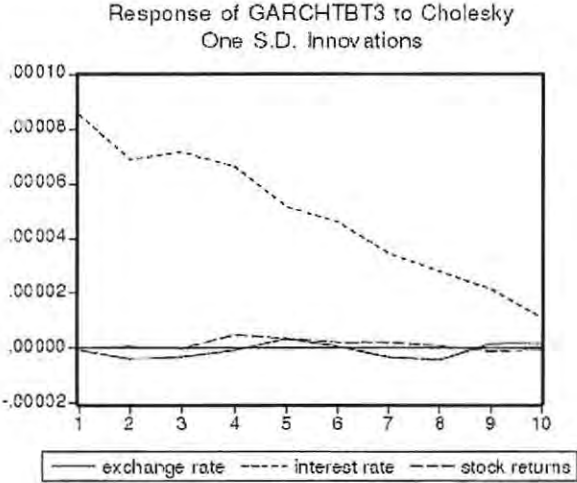
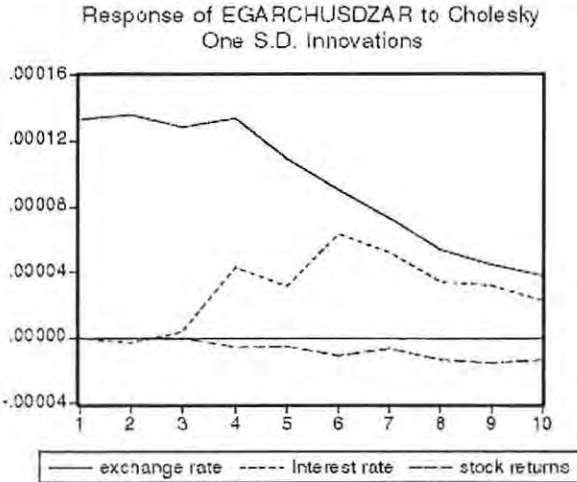


Figure 6.5: Impulse Responses combined graphs



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	TBT3	USDZAR	ALL	LNTBT3	LNUSDZA	LNALL	T
07/01/1996	14.14	3.6341	5875.61	2.649008	1.290361	8.678565	1
14/01/1996	13.97	3.6289	6051.985	2.636912	1.28893	8.708142	2
21/01/1996	13.93	3.6423	6142.578	2.634045	1.292615	8.723	3
28/01/1996	13.93	3.6492	6275.905	2.634045	1.294508	8.744473	4
04/02/1996	13.94	3.6512	6306.756	2.634762	1.295056	8.749377	5
11/02/1996	13.9	3.644	6178.71	2.631889	1.293082	8.728865	6
18/02/1996	13.97	3.6747	6140.479	2.636912	1.301471	8.722658	7
25/02/1996	13.97	3.8861	6089.215	2.636912	1.357406	8.714274	8
03/03/1996	14.07	3.8405	6022.046	2.644045	1.345603	8.703182	9
10/03/1996	14.15	3.8948	6008.712	2.649715	1.359642	8.700966	10
17/03/1996	14.18	3.9253	6018.14	2.651833	1.367443	8.702534	11
24/03/1996	14.16	3.9258	6008.636	2.650421	1.36757	8.700953	12
31/03/1996	14.13	3.9638	6071.503	2.6483	1.377203	8.711361	13
07/04/1996	14.14	4.0437	6026.18	2.649008	1.39716	8.703869	14
14/04/1996	14.18	4.1513	6010	2.651833	1.423422	8.70118	15
21/04/1996	14.2	4.2252	6312.564	2.653242	1.441067	8.750297	16
28/04/1996	15.09	4.303	6394.047	2.714032	1.459312	8.763123	17
05/05/1996	15.23	4.3581	6304.073	2.723267	1.472036	8.748951	18
12/05/1996	16.02	4.4148	6133.439	2.773838	1.484963	8.721511	19
19/05/1996	16.21	4.3302	6127.237	2.785628	1.465614	8.720499	20
26/05/1996	16.1	4.3371	6088.865	2.778819	1.467206	8.714217	21
02/06/1996	16.06	4.3711	6213.431	2.776332	1.475015	8.734469	22
09/06/1996	15.95	4.3586	6183.445	2.769459	1.472151	8.729631	23
16/06/1996	15.78	4.3389	6174.552	2.758743	1.467621	8.728192	24
23/06/1996	15.7	4.353	6202.242	2.753661	1.470865	8.732666	25
30/06/1996	15.1	4.3411	6212.22	2.714695	1.468128	8.734274	26
07/07/1996	14.95	4.3321	6243.212	2.704711	1.466052	8.73925	27
14/07/1996	14.94	4.3446	6149.684	2.704042	1.468934	8.724156	28
21/07/1996	15.03	4.4071	6147.958	2.710048	1.483217	8.723875	29
28/07/1996	15.11	4.4186	6007.256	2.715357	1.485823	8.700723	30
04/08/1996	15.31	4.4774	6056.259	2.728506	1.499043	8.708848	31
11/08/1996	15.99	4.4852	6025.865	2.771964	1.500783	8.703816	32
18/08/1996	16.2	4.5417	5911.434	2.785011	1.513301	8.684644	33
25/08/1996	16.09	4.5536	5944.782	2.778198	1.515918	8.690269	34
01/09/1996	15.79	4.513	6083.698	2.759377	1.506962	8.713368	35
08/09/1996	15.36	4.4869	6185.09	2.731767	1.501162	8.729897	36
15/09/1996	15.17	4.4934	6247.951	2.71932	1.50261	8.740009	37
22/09/1996	15.05	4.4872	6302.264	2.711378	1.501229	8.748664	38
29/09/1996	15.06	4.5184	6289.372	2.712042	1.508158	8.746617	39
06/10/1996	15.04	4.5242	6366.334	2.710713	1.509441	8.758779	40
13/10/1996	15.04	4.539	6387.977	2.710713	1.512707	8.762173	41
20/10/1996	15.01	4.544	6336.721	2.708717	1.513808	8.754117	42
27/10/1996	14.95	4.576	6318.439	2.704711	1.520825	8.751227	43
03/11/1996	14.98	4.687	6298.654	2.706716	1.544793	8.748091	44
10/11/1996	14.93	4.6973	6140.747	2.703373	1.546988	8.722702	45
17/11/1996	14.99	4.6835	6193.985	2.707383	1.544046	8.731334	46
24/11/1996	15.97	4.6352	6079.526	2.770712	1.533679	8.712682	47
01/12/1996	15.71	4.5846	6078.311	2.754297	1.522703	8.712482	48
08/12/1996	15.93	4.6523	5952.758	2.768204	1.537362	8.69161	49
15/12/1996	15.94	4.6966	5840.997	2.768832	1.546839	8.672657	50
22/12/1996	15.98	4.6944	5891.325	2.771338	1.54637	8.681236	51

	TBT3	USDZAR	ALL	LNTBT3	LNUSDZA	LNALL	T
29/12/1996	16.1	4.6885	5934.389	2.778819	1.545113	8.688519	52
05/01/1997	16.18	4.6861	5941.8	2.783776	1.544601	8.689767	53
12/01/1997	16.26	4.678	6021.338	2.788708	1.542871	8.703065	54
19/01/1997	16.28	4.662	6136.17	2.789937	1.539445	8.721956	55
26/01/1997	16.27	4.6327	6040.611	2.789323	1.53314	8.70626	56
02/02/1997	15.84	4.5719	6023.594	2.762538	1.519929	8.703439	57
09/02/1997	15.82	4.5004	6193.2	2.761275	1.504166	8.731207	58
16/02/1997	15.74	4.4113	6333.171	2.756205	1.484169	8.753556	59
23/02/1997	15.78	4.4583	6438.611	2.758743	1.494768	8.770068	60
02/03/1997	15.8	4.444	6434.25	2.76001	1.491555	8.769391	61
09/03/1997	15.82	4.4566	6356.435	2.761275	1.494386	8.757223	62
16/03/1997	15.82	4.4214	6411.633	2.761275	1.486456	8.765869	63
23/03/1997	15.82	4.4283	6377.11	2.761275	1.488016	8.76047	64
30/03/1997	15.79	4.4223	6369.005	2.759377	1.48666	8.759199	65
06/04/1997	15.78	4.4148	6313.893	2.758743	1.484963	8.750508	66
13/04/1997	15.79	4.4375	6325.75	2.759377	1.490091	8.752384	67
20/04/1997	15.77	4.4554	6341.517	2.758109	1.494117	8.754873	68
27/04/1997	15.69	4.4451	6389.389	2.753024	1.491802	8.762394	69
04/05/1997	15.7	4.4449	6458.765	2.753661	1.491757	8.773193	70
11/05/1997	15.7	4.4584	6483.297	2.753661	1.49479	8.776984	71
18/05/1997	15.7	4.4725	6430.945	2.753661	1.497948	8.768877	72
25/05/1997	15.65	4.4643	6351.014	2.750471	1.496112	8.75637	73
01/06/1997	15.64	4.4726	6295.759	2.749832	1.49797	8.747632	74
08/06/1997	15.46	4.4735	6527.665	2.738256	1.498171	8.783805	75
15/06/1997	15.45	4.4976	6535.07	2.737609	1.503544	8.784938	76
22/06/1997	15.47	4.5092	6513.021	2.738903	1.50612	8.781559	77
29/06/1997	15.24	4.505	6669.156	2.723924	1.505188	8.805249	78
06/07/1997	15.11	4.5279	6649.947	2.715357	1.510258	8.802364	79
13/07/1997	15.07	4.5477	6633.9	2.712706	1.514622	8.799948	80
20/07/1997	15.08	4.5542	6702.031	2.713369	1.51605	8.810166	81
27/07/1997	14.98	4.5635	6716.719	2.706716	1.51809	8.812355	82
03/08/1997	14.82	4.5939	6724.03	2.695978	1.524729	8.813443	83
10/08/1997	14.81	4.6595	6848.45	2.695303	1.538908	8.831778	84
17/08/1997	14.79	4.672	6665.919	2.693951	1.541587	8.804763	85
24/08/1997	14.75	4.7134	6575.859	2.691243	1.55041	8.79116	86
31/08/1997	14.74	4.6903	6539.403	2.690565	1.545497	8.785601	87
07/09/1997	14.73	4.6992	6634.053	2.689886	1.547392	8.799971	88
14/09/1997	14.72	4.6939	6397.224	2.689207	1.546264	8.763619	89
21/09/1997	14.7	4.6779	6401.86	2.687847	1.542849	8.764344	90
28/09/1997	14.69	4.6905	6369.853	2.687167	1.545539	8.759332	91
05/10/1997	14.69	4.6654	6465.994	2.687167	1.540174	8.774312	92
12/10/1997	14.72	4.6676	6488.173	2.689207	1.540645	8.777736	93
19/10/1997	14.69	4.675	6495.515	2.687167	1.542229	8.778867	94
26/10/1997	14.1	4.7112	6384.483	2.646175	1.549943	8.761626	95
02/11/1997	14.49	4.8075	5830.671	2.673459	1.570177	8.670887	96
09/11/1997	14.53	4.814	5763.13	2.676215	1.571528	8.659236	97
16/11/1997	14.55	4.8277	5605.26	2.677591	1.57437	8.631461	98
23/11/1997	14.59	4.8507	5630.826	2.680336	1.579123	8.636011	99
30/11/1997	14.59	4.8488	5565.662	2.680336	1.578731	8.624371	100
07/12/1997	14.6	4.8632	5422.419	2.681022	1.581697	8.598297	101
14/12/1997	14.6	4.8808	5232.085	2.681022	1.585309	8.562565	102

	TBT3	USDZAR	ALL	LNTBT3	LNUSDZA	LNALL	T
21/12/1997	14.61	4.8689	5339.063	2.681706	1.582868	8.582805	103
28/12/1997	14.79	4.8608	5372.09	2.693951	1.581203	8.588972	104
04/01/1998	14.65	4.8621	5465.6	2.68444	1.58147	8.606229	105
11/01/1998	14.49	4.927	5282.289	2.673459	1.59473	8.572115	106
18/01/1998	14.36	4.9656	5162.993	2.664447	1.602534	8.549272	107
25/01/1998	14.28	4.9598	5357.413	2.65886	1.601365	8.586236	108
01/02/1998	14.25	4.9166	5835.504	2.656757	1.592617	8.671716	109
08/02/1998	14.16	4.9206	5901.009	2.650421	1.59343	8.682879	110
15/02/1998	13.97	4.9262	5902.19	2.636912	1.594568	8.683079	111
22/02/1998	13.88	4.9417	6031.7	2.630449	1.597709	8.704784	112
01/03/1998	13.69	4.9424	6283.135	2.616666	1.597851	8.745624	113
08/03/1998	13.51	4.9411	6122.73	2.60343	1.597588	8.719763	114
15/03/1998	13.07	4.98	6420.216	2.57032	1.60543	8.767207	115
22/03/1998	12.9	4.9723	6393.991	2.557227	1.603883	8.763114	116
29/03/1998	12.92	4.974	6667.179	2.558776	1.604224	8.804952	117
05/04/1998	12.96	5.0281	7004.267	2.561868	1.615042	8.854275	118
12/04/1998	12.95	5.0451	7094.964	2.561096	1.618417	8.867141	119
19/04/1998	12.86	5.0396	7316.103	2.554122	1.617327	8.897833	120
26/04/1998	12.84	5.0487	7368.894	2.552565	1.619131	8.905023	121
03/05/1998	12.81	5.0503	7392.663	2.550226	1.619448	8.908243	122
10/05/1998	12.78	5.0582	7242.275	2.547881	1.621011	8.887691	123
17/05/1998	12.91	5.0743	7211.843	2.558002	1.624189	8.88348	124
24/05/1998	13.07	5.0941	7228.172	2.57032	1.628083	8.885741	125
31/05/1998	14.4	5.1496	6795.298	2.667228	1.638919	8.823986	126
07/06/1998	14.49	5.1404	6668.891	2.673459	1.637131	8.805209	127
14/06/1998	16.79	5.2001	6137.758	2.820783	1.648678	8.722215	128
21/06/1998	16.84	5.3771	6158.123	2.823757	1.682149	8.725527	129
28/06/1998	17.4	5.5425	6147.186	2.85647	1.712446	8.72375	130
05/07/1998	18.84	6.0875	6296.783	2.935982	1.806237	8.747794	131
12/07/1998	19.08	6.2955	6402.567	2.948641	1.839835	8.764454	132
19/07/1998	19.28	6.162	6693.81	2.959068	1.818401	8.808938	133
26/07/1998	19.24	6.2577	6292.421	2.956991	1.833813	8.747101	134
02/08/1998	19.32	6.1975	6350.31	2.961141	1.824146	8.756259	135
09/08/1998	19.34	6.1901	6000.106	2.962175	1.822951	8.699532	136
16/08/1998	19.5	6.327	5653.616	2.970414	1.844826	8.640051	137
23/08/1998	19.67	6.3005	5442.892	2.979095	1.840629	8.602066	138
30/08/1998	21.76	6.4166	4518.994	3.080073	1.858888	8.416045	139
06/09/1998	22.23	6.3045	4409.385	3.101443	1.841264	8.391491	140
13/09/1998	22.3	6.2265	4319.947	3.104587	1.828814	8.370998	141
20/09/1998	21.18	6.1582	4459.501	3.053057	1.817785	8.402792	142
27/09/1998	20.09	5.9713	4745.752	3.000222	1.786965	8.465005	143
04/10/1998	20.09	5.9262	4568.121	3.000222	1.779383	8.426857	144
11/10/1998	19.89	5.8968	4632.634	2.990217	1.77441	8.440881	145
18/10/1998	19.28	5.731	5200.694	2.959068	1.74589	8.556547	146
25/10/1998	18.75	5.7118	5141.2	2.931194	1.742534	8.545042	147
01/11/1998	18.5	5.7215	5350.762	2.917771	1.744231	8.584994	148
08/11/1998	17.6	5.5856	5524.099	2.867899	1.720192	8.616875	149
15/11/1998	17.57	5.6613	5270.244	2.866193	1.733654	8.569832	150
22/11/1998	17.5	5.6713	5318.171	2.862201	1.735418	8.578885	151
29/11/1998	17.43	5.678	5222.439	2.858193	1.736599	8.56072	152
06/12/1998	17.19	5.7036	4840.966	2.844328	1.741098	8.48487	153

	TBT3	USDZAR	ALL	LNTBT3	LNUSDZA	LNALL	T
13/12/1998	17.24	5.9306	4854.779	2.847232	1.780125	8.487719	154
20/12/1998	17.24	5.9596	4755.563	2.847232	1.785003	8.46707	155
27/12/1998	17.03	5.9094	4860.531	2.834976	1.776544	8.488903	156
03/01/1999	16.78	5.8775	5015.719	2.820188	1.771132	8.520332	157
10/01/1999	16.25	5.7955	5398.303	2.788093	1.757082	8.59384	158
17/01/1999	16.5	6.0735	5233.246	2.80336	1.803935	8.562787	159
24/01/1999	16.32	6.0318	5216.304	2.792391	1.797045	8.559544	160
31/01/1999	16.04	6.0336	5420.877	2.775086	1.797344	8.598013	161
07/02/1999	15.56	6.0105	5453.669	2.744704	1.793508	8.604044	162
14/02/1999	15.42	6.053	5559.371	2.735665	1.800554	8.62324	163
21/02/1999	15.31	6.143	5500.673	2.728506	1.815313	8.612626	164
28/02/1999	15.08	6.2005	5543.499	2.713369	1.82463	8.620381	165
07/03/1999	14.74	6.2085	5833.345	2.690565	1.825919	8.671346	166
14/03/1999	14.45	6.1634	6017.521	2.670694	1.818629	8.702431	167
21/03/1999	14.51	6.2209	6170.652	2.674838	1.827915	8.72756	168
28/03/1999	14.43	6.21	6046.374	2.669309	1.826161	8.707214	169
04/04/1999	14.12	6.1979	5992.994	2.647592	1.824211	8.698346	170
11/04/1999	13.8	6.1925	6075.069	2.624669	1.823339	8.711949	171
18/04/1999	13.71	6.1199	6540.384	2.618125	1.811546	8.785751	172
25/04/1999	13.45	6.0821	6377.376	2.598979	1.80535	8.760512	173
02/05/1999	13.35	6.0672	6678.445	2.591516	1.802897	8.80664	174
09/05/1999	13.26	6.0866	6498.268	2.584752	1.80609	8.779291	175
16/05/1999	13.67	6.1654	6336.334	2.615204	1.818953	8.754056	176
23/05/1999	13.64	6.169	6371.145	2.613007	1.819537	8.759534	177
30/05/1999	13.7	6.2224	6139.59	2.617396	1.828156	8.722513	178
06/06/1999	13.53	6.1981	6427.215	2.604909	1.824243	8.768297	179
13/06/1999	13.35	6.1064	6669.504	2.591516	1.809337	8.805301	180
20/06/1999	13.06	6.0575	6676.753	2.569554	1.801297	8.806387	181
27/06/1999	12.9	6.0204	6628.112	2.557227	1.795154	8.799075	182
04/07/1999	12.58	6.0433	6889.486	2.532108	1.79895	8.837752	183
11/07/1999	12.12	6.041	6897.24	2.494857	1.79857	8.838877	184
18/07/1999	11.99	6.1208	6850.443	2.484073	1.811693	8.832069	185
25/07/1999	11.74	6.1243	6836.53	2.463002	1.812264	8.830036	186
01/08/1999	11.62	6.1404	6825.391	2.452728	1.81489	8.828405	187
08/08/1999	11.71	6.1744	6891.606	2.460443	1.820412	8.838059	188
15/08/1999	11.72	6.1424	6955.092	2.461297	1.815216	8.847229	189
22/08/1999	11.68	6.1077	6850.666	2.457878	1.80955	8.832101	190
29/08/1999	11.65	6.0908	6757.6	2.455306	1.806779	8.818423	191
05/09/1999	11.37	6.0554	6636.609	2.430978	1.80095	8.800356	192
12/09/1999	11.13	6.0582	6504.055	2.409644	1.801413	8.780181	193
19/09/1999	11.09	6.0929	6427.707	2.406044	1.807124	8.768373	194
26/09/1999	10.93	6.0697	6378.072	2.391511	1.803309	8.760621	195
03/10/1999	10.83	5.9988	6698.058	2.38232	1.791559	8.809573	196
10/10/1999	10.76	6.0205	7160.424	2.375836	1.79517	8.876324	197
17/10/1999	10.72	6.094	6815.545	2.372111	1.807305	8.826961	198
24/10/1999	10.74	6.1346	6840.479	2.373975	1.813945	8.830613	199
31/10/1999	10.73	6.1425	6948.86	2.373044	1.815232	8.846333	200
07/11/1999	10.71	6.136	7025.462	2.371178	1.814173	8.857296	201
14/11/1999	10.71	6.1184	7084.085	2.371178	1.811301	8.865606	202
21/11/1999	10.7	6.1374	7351.993	2.370244	1.814401	8.902727	203
28/11/1999	10.7	6.1277	7417.821	2.370244	1.812819	8.911641	204

	TBT3	USDZAR	ALL	LNTBT3	LNUSDZA	LNALL	T
05/12/1999	10.71	6.1525	7566.655	2.371178	1.816859	8.931506	205
12/12/1999	10.7	6.1449	7892.301	2.370244	1.815622	8.973643	206
19/12/1999	10.69	6.125	8174.107	2.369309	1.812379	9.008727	207
26/12/1999	10.71	6.1362	8282.009	2.371178	1.814206	9.021841	208
02/01/2000	10.71	6.1438	8357.193	2.371178	1.815443	9.030878	209
09/01/2000	10.57	6.0884	8471.778	2.35802	1.806385	9.044496	210
16/01/2000	9.96	6.0687	8797.663	2.298577	1.803144	9.082241	211
23/01/2000	9.76	6.0879	8826.704	2.278292	1.806303	9.085537	212
30/01/2000	9.78	6.1665	8313.896	2.280339	1.819131	9.025684	213
06/02/2000	9.8	6.2786	8464.74	2.282382	1.837147	9.043665	214
13/02/2000	9.78	6.3103	8462.866	2.280339	1.842183	9.043443	215
20/02/2000	9.78	6.3345	8302.275	2.280339	1.846011	9.024285	216
27/02/2000	9.77	6.3079	7887.761	2.279316	1.841803	8.973068	217
05/03/2000	9.83	6.3555	7779.481	2.285439	1.849321	8.959245	218
12/03/2000	9.88	6.4597	7673.951	2.290513	1.865583	8.945587	219
19/03/2000	9.87	6.439	7781.956	2.2895	1.862373	8.959563	220
26/03/2000	9.83	6.4713	7985.536	2.285439	1.867377	8.985387	221
02/04/2000	9.83	6.5129	7765.414	2.285439	1.873785	8.957435	222
09/04/2000	9.84	6.5621	7646.533	2.286456	1.881311	8.942008	223
16/04/2000	9.84	6.568	6982.734	2.286456	1.882209	8.851196	224
23/04/2000	9.95	6.6204	6984.477	2.297573	1.890156	8.851445	225
30/04/2000	10.11	6.7578	7250.6	2.313525	1.910697	8.88884	226
07/05/2000	10.1	6.8404	7267.392	2.312535	1.922846	8.891153	227
14/05/2000	10.12	7.0266	7331.69	2.314514	1.949703	8.899961	228
21/05/2000	10.3	7.088	7112.361	2.332144	1.958403	8.86959	229
28/05/2000	10.47	7.1198	7076.708	2.348514	1.96288	8.864564	230
04/06/2000	10.28	7.0233	7325.83	2.3302	1.949233	8.899162	231
11/06/2000	10.24	6.9665	7619.161	2.326302	1.941113	8.938422	232
18/06/2000	10.29	6.9888	7558.119	2.331173	1.944309	8.930378	233
25/06/2000	10.29	6.8937	7438.489	2.331173	1.930608	8.914423	234
02/07/2000	10.25	6.8245	7570.388	2.327278	1.920519	8.932	235
09/07/2000	10.23	6.8004	7582.901	2.325325	1.916981	8.933651	236
16/07/2000	10.24	6.8274	7877.925	2.326302	1.920944	8.97182	237
23/07/2000	10.23	6.9244	7801.046	2.325325	1.935051	8.962013	238
30/07/2000	10.21	6.9367	7663.795	2.323368	1.936826	8.944263	239
06/08/2000	10.17	6.9781	7778.558	2.319442	1.942777	8.959126	240
13/08/2000	10.14	6.9551	7991.132	2.316488	1.939475	8.986088	241
20/08/2000	10.13	6.9202	8130.903	2.315501	1.934445	9.003427	242
27/08/2000	10.13	6.9559	8243.158	2.315501	1.93959	9.017139	243
03/09/2000	10.13	6.9488	8414.793	2.315501	1.938569	9.037747	244
10/09/2000	10.16	7.0396	8418.306	2.318458	1.951551	9.038164	245
17/09/2000	10.17	7.1325	8312.99	2.319442	1.964662	9.025575	246
24/09/2000	10.18	7.2793	7962.658	2.320425	1.985035	8.982518	247
01/10/2000	10.18	7.2374	8146.748	2.320425	1.979262	9.005374	248
08/10/2000	10.13	7.2324	8116.63	2.315501	1.978571	9.00167	249
15/10/2000	10.15	7.3876	7851.84	2.317474	1.999803	8.968503	250
22/10/2000	10.25	7.5969	7936.154	2.327278	2.02774	8.979184	251
29/10/2000	10.25	7.625	7787.921	2.327278	2.031432	8.960329	252
05/11/2000	10.23	7.5368	8291.236	2.325325	2.019798	9.022954	253
12/11/2000	10.21	7.626	8086.965	2.323368	2.031563	8.998009	254
19/11/2000	10.21	7.6503	8068.576	2.323368	2.034745	8.995732	255

	TBT3	USDZAR	ALL	LNTBT3	LNUSDZA	LNALL	T
26/11/2000	10.21	7.7841	7811.425	2.323368	2.052083	8.963343	256
03/12/2000	10.21	7.7526	7676.829	2.323368	2.048028	8.945962	257
10/12/2000	10.19	7.611	8038.99	2.321407	2.029595	8.992059	258
17/12/2000	10.16	7.7064	7946.625	2.318458	2.042051	8.980503	259
24/12/2000	10.24	7.6473	8081.346	2.326302	2.034353	8.997314	260
31/12/2000	10.25	7.5549	8164.293	2.327278	2.022196	9.007525	261
07/01/2001	10.16	7.5296	8280.54	2.318458	2.018842	9.021663	262
14/01/2001	10.15	7.7449	8517.209	2.317474	2.047035	9.049844	263
21/01/2001	10.11	7.8488	8782.647	2.313525	2.060361	9.080533	264
28/01/2001	10.12	7.8812	8799.088	2.314514	2.06448	9.082403	265
04/02/2001	10.11	7.795	9141.688	2.313525	2.053483	9.1206	266
11/02/2001	10.11	7.8442	9049.535	2.313525	2.059774	9.110469	267
18/02/2001	10.13	7.8591	9175.738	2.315501	2.061672	9.124318	268
25/02/2001	10.13	7.7961	8962.805	2.315501	2.053624	9.100839	269
04/03/2001	10.13	7.7322	8827.48	2.315501	2.045393	9.085625	270
11/03/2001	10.14	7.7921	8985.335	2.316488	2.05311	9.103349	271
18/03/2001	10.16	7.8239	8239.76	2.318458	2.057183	9.016726	272
25/03/2001	10.19	7.9866	8181.999	2.321407	2.077765	9.009692	273
01/04/2001	10.32	7.9887	8103.152	2.334084	2.078028	9.000008	274
08/04/2001	10.33	8.0821	8050.641	2.335052	2.089652	8.993507	275
15/04/2001	10.32	8.035	8512.182	2.334084	2.083807	9.049254	276
22/04/2001	10.35	8.1257	8835.304	2.336987	2.095032	9.086511	277
29/04/2001	10.4	8.1109	8768.575	2.341806	2.093209	9.07893	278
06/05/2001	10.4	8.0328	8857.138	2.341806	2.083533	9.088979	279
13/05/2001	10.4	7.9692	8873.156	2.341806	2.075584	9.090786	280
20/05/2001	10.36	7.9776	9315.867	2.337952	2.076638	9.139474	281
27/05/2001	10.36	7.9186	9239.77	2.337952	2.069214	9.131272	282
03/06/2001	10.38	7.9573	9157.029	2.339881	2.07409	9.122277	283
10/06/2001	10.37	8.0544	9190.358	2.338917	2.086219	9.12591	284
17/06/2001	9.6	8.076	9020.592	2.261763	2.088897	9.107265	285
24/06/2001	9.64	8.0589	9064.854	2.265921	2.086777	9.11216	286
01/07/2001	9.65	8.0329	9089.885	2.266958	2.083546	9.114918	287
08/07/2001	9.65	8.0879	8693.795	2.266958	2.090369	9.070365	288
15/07/2001	9.55	8.2472	8864.624	2.256541	2.109874	9.089824	289
22/07/2001	9.42	8.2453	8600.987	2.242835	2.109643	9.059632	290
29/07/2001	9.38	8.1934	8366.789	2.23858	2.103329	9.032025	291
05/08/2001	9.38	8.2344	8723.49	2.23858	2.108321	9.073775	292
12/08/2001	9.36	8.2843	8404.637	2.236445	2.114362	9.036539	293
19/08/2001	9.35	8.2583	8556.638	2.235376	2.111219	9.054463	294
26/08/2001	9.38	8.3603	8837.219	2.23858	2.123494	9.086728	295
02/09/2001	9.37	8.3767	8886.722	2.237513	2.125454	9.092314	296
09/09/2001	9.35	8.4674	8621.069	2.235376	2.136223	9.061964	297
16/09/2001	9.37	8.5824	7972.215	2.237513	2.149714	8.983718	298
23/09/2001	8.97	8.6708	7189.993	2.193886	2.159961	8.880445	299
30/09/2001	8.89	8.8699	7997.93	2.184927	2.182664	8.986938	300
07/10/2001	8.88	9.201	8358.312	2.183802	2.219312	9.031012	301
14/10/2001	8.87	9.2357	8465.278	2.182675	2.223076	9.043728	302
21/10/2001	8.85	9.188	8418.543	2.180417	2.217898	9.038192	303
28/10/2001	8.85	9.4254	8498.135	2.180417	2.243408	9.047602	304
04/11/2001	8.83	9.436	8648.751	2.178155	2.244532	9.06517	305
11/11/2001	8.66	9.5391	8655.327	2.158715	2.255399	9.06593	306

	TBT3	USDZAR	ALL	LNTBT3	LNUSDZA	LNALL	T
18/11/2001	8.73	9.6432	9060.893	2.166765	2.266253	9.111723	307
25/11/2001	8.77	9.8146	9213.048	2.171337	2.283871	9.128376	308
02/12/2001	8.94	10.005	9404.056	2.190536	2.303085	9.148896	309
09/12/2001	9.1	10.6936	9983.233	2.208274	2.369645	9.208662	310
16/12/2001	9.28	11.3258	10422.54	2.227862	2.427083	9.251726	311
23/12/2001	9.4	12.6809	10412.98	2.24071	2.540097	9.250808	312
30/12/2001	9.47	12.0194	10369.69	2.248129	2.486522	9.246642	313
06/01/2002	9.44	12.1813	10843.37	2.244956	2.499902	9.291309	314
13/01/2002	9.27	11.5646	10927.15	2.226783	2.447949	9.299006	315
20/01/2002	9.52	11.5334	10357.01	2.253395	2.445247	9.245419	316
27/01/2002	9.51	11.4187	10277.44	2.252344	2.435252	9.237707	317
03/02/2002	9.45	11.4682	10584.52	2.246015	2.439578	9.267147	318
10/02/2002	9.3	11.5192	10691.72	2.230014	2.444015	9.277225	319
17/02/2002	9.45	11.4925	11094.05	2.246015	2.441695	9.314164	320
24/02/2002	9.51	11.4695	10650.42	2.252344	2.439691	9.273354	321
03/03/2002	9.56	11.4264	10802.16	2.257588	2.435926	9.287502	322
10/03/2002	9.68	11.2258	11243.54	2.270062	2.418215	9.327549	323
17/03/2002	10.1	11.6141	11161.25	2.312535	2.45222	9.320203	324
24/03/2002	10.24	11.6716	11120.14	2.326302	2.457159	9.316513	325
31/03/2002	10.11	11.4993	11015.04	2.313525	2.442286	9.307017	326
07/04/2002	10.48	11.217	11348.79	2.349469	2.41743	9.336866	327
14/04/2002	10.53	11.1945	11200.65	2.354228	2.415423	9.323727	328
21/04/2002	10.63	11.1626	11490.49	2.36368	2.412569	9.349275	329
28/04/2002	10.96	10.9339	11155.35	2.394252	2.391868	9.319675	330
05/05/2002	10.99	10.57	11127.48	2.396986	2.35802	9.317173	331
12/05/2002	11.01	10.2922	11519.5	2.398804	2.331386	9.351796	332
19/05/2002	11.24	10.1567	11433.21	2.419479	2.318134	9.344278	333
26/05/2002	11.38	10.0687	11607.86	2.431857	2.309432	9.359438	334
02/06/2002	11.39	9.8757	11200.85	2.432736	2.290077	9.323745	335
09/06/2002	11.39	9.8096	11061.42	2.432736	2.283361	9.311219	336
16/06/2002	11.5	10.1303	10912.93	2.442347	2.315531	9.297704	337
23/06/2002	11.48	10.3168	10815.08	2.440606	2.333774	9.288697	338
30/06/2002	11.42	10.3313	10657.73	2.435366	2.335178	9.274041	339
07/07/2002	11.39	10.1288	10538.31	2.432736	2.315383	9.262772	340
14/07/2002	11.35	10.0597	10161.44	2.429218	2.308537	9.226355	341
21/07/2002	11.35	10.0241	10219.67	2.429218	2.304992	9.23207	342
28/07/2002	11.35	10.1289	9468.89	2.429218	2.315393	9.155767	343
04/08/2002	11.35	10.1818	9019.81	2.429218	2.320602	9.107179	344
11/08/2002	11.35	10.4844	9272.59	2.429218	2.349888	9.134818	345
18/08/2002	11.37	10.5493	9437.7	2.430978	2.35606	9.152468	346
25/08/2002	11.55	10.7855	9802.42	2.446685	2.378203	9.190385	347
01/09/2002	11.73	10.6409	9677.26	2.46215	2.364705	9.177534	348
08/09/2002	11.9	10.624	9540.1	2.476538	2.363116	9.163259	349
15/09/2002	12.21	10.5504	9683.92	2.502255	2.356164	9.178222	350
22/09/2002	12.37	10.5901	9546.52	2.515274	2.35992	9.163932	351
29/09/2002	12.41	10.6003	9640.9	2.518503	2.360882	9.17377	352
06/10/2002	12.78	10.4609	9531.48	2.547881	2.347644	9.162355	353
13/10/2002	12.67	10.4488	9398.86	2.539237	2.346487	9.148344	354
20/10/2002	12.61	10.3938	9602.86	2.53449	2.341209	9.169816	355
27/10/2002	12.49	10.1889	9617.89	2.524928	2.321299	9.17138	356
03/11/2002	12.32	10.058	9636.27	2.511224	2.308368	9.173289	357

	TBT3	USDZAR	ALL	LNTBT3	LNUSDZA	LNALL	T
10/11/2002	12.08	9.8635	9656.97	2.491551	2.288841	9.175435	358
17/11/2002	11.98	9.7763	9697.44	2.483239	2.279961	9.179617	359
24/11/2002	12.26	9.5991	9726.04	2.506342	2.261669	9.182562	360
01/12/2002	12.28	9.2516	9563.74	2.507972	2.224797	9.165734	361
08/12/2002	12.17	9.1889	9326.54	2.498974	2.217996	9.140619	362
15/12/2002	12.23	8.9614	9083.83	2.503892	2.192926	9.114251	363
22/12/2002	12.29	8.8863	9343.35	2.508786	2.184511	9.14242	364
29/12/2002	12.42	8.8147	9399.08	2.519308	2.176421	9.148367	365
05/01/2003	12.41	8.5832	9343.92	2.518503	2.149807	9.142481	366
12/01/2003	12.37	8.5239	9308.98	2.515274	2.142874	9.138735	367
19/01/2003	12.35	8.7474	9488.42	2.513656	2.168757	9.157827	368
26/01/2003	12.23	8.8699	9210.57	2.503892	2.182664	9.128107	369
02/02/2003	12.38	8.6569	8798.35	2.516082	2.158357	9.082319	370
09/02/2003	12.6	8.4149	8806.33	2.533697	2.130004	9.083226	371
16/02/2003	12.74	8.385	8596.97	2.544747	2.126444	9.059165	372
23/02/2003	12.73	8.2622	8497.34	2.543961	2.111691	9.047508	373
02/03/2003	12.73	8.0704	8402.09	2.543961	2.088203	9.036236	374
09/03/2003	12.74	7.971	7973.71	2.544747	2.07581	8.983905	375
16/03/2003	12.71	8.0092	8081.24	2.542389	2.080591	8.997301	376
23/03/2003	12.74	8.1608	8139.31	2.544747	2.099342	9.004461	377
30/03/2003	12.75	8.0257	7735.86	2.545531	2.082649	8.953622	378
06/04/2003	12.72	7.9084	7878.98	2.543176	2.067925	8.971954	379
13/04/2003	12.74	7.9114	7818.13	2.544747	2.068305	8.964201	380
20/04/2003	12.76	7.7048	7761.55	2.546315	2.041844	8.956937	381
27/04/2003	12.75	7.4447	7361.15	2.545531	2.007502	8.903971	382
04/05/2003	12.73	7.2444	7659.39	2.543961	1.980229	8.943688	383
11/05/2003	12.67	7.3006	7593.49	2.539237	1.987957	8.935047	384
18/05/2003	12.6	7.5716	8158.66	2.533697	2.024404	9.006835	385
25/05/2003	12.39	7.7974	8254.52	2.51689	2.05379	9.018516	386
01/06/2003	12.03	8.0541	8564.33	2.487404	2.086181	9.055361	387
08/06/2003	11.57	8.0597	8860.6	2.448416	2.086876	9.08937	388
15/06/2003	10.94	7.9092	8712.87	2.392426	2.068027	9.072557	389
22/06/2003	10.78	7.8711	8854.12	2.377693	2.063198	9.088638	390
29/06/2003	10.68	7.7235	8347.23	2.368373	2.044268	9.029685	391
06/07/2003	10.8	7.4547	8498.74	2.379546	2.008845	9.047673	392
13/07/2003	11.03	7.5616	8644.78	2.400619	2.023083	9.064711	393
20/07/2003	11.11	7.67	8579.63	2.407846	2.037317	9.057146	394
27/07/2003	10.74	7.5458	8747.23	2.373975	2.020991	9.076492	395
03/08/2003	10.63	7.3439	8806.91	2.36368	1.99387	9.083292	396
10/08/2003	10.28	7.3787	8863.61	2.3302	1.998597	9.089709	397
17/08/2003	10.18	7.3856	9018.65	2.320425	1.999532	9.10705	398
24/08/2003	10	7.3813	9338.75	2.302585	1.99895	9.141928	399
31/08/2003	9.96	7.3813	9226.2	2.298577	1.99895	9.129803	400
07/09/2003	10.04	7.3257	9498.09	2.306577	1.991389	9.158846	401
14/09/2003	9.21	7.445	9374.14	2.22029	2.007543	9.14571	402
21/09/2003	8.97	7.4051	9413.15	2.193886	2.002169	9.149863	403
28/09/2003	8.81	7.1698	9105.51	2.175887	1.969878	9.116635	404
05/10/2003	8.68	6.9746	9106.78	2.161022	1.942275	9.116774	405
12/10/2003	8.41	6.9043	9488.46	2.129421	1.932144	9.157832	406
19/10/2003	7.88	7.0186	9854.68	2.064328	1.948564	9.195702	407
26/10/2003	7.8	7.0598	9498.25	2.054124	1.954417	9.158863	408

	TBT3	USDZAR	ALL	LNTBT3	LNUSDZA	LNALL	T
02/11/2003	7.81	6.9065	9765.3	2.055405	1.932463	9.186591	409
09/11/2003	7.86	6.94	9928.84	2.061787	1.937302	9.203199	410
16/11/2003	7.86	6.862	9914.01	2.061787	1.925999	9.201704	411
23/11/2003	7.45	6.6125	9576.46	2.008214	1.888962	9.167063	412
30/11/2003	7.14	6.4832	9729.6	1.965713	1.869214	9.182928	413
07/12/2003	7.02	6.3051	9783.57	1.948763	1.841359	9.18846	414
14/12/2003	7.4	6.3966	9783.4	2.00148	1.855767	9.188442	415
21/12/2003	7.49	6.4975	10229.76	2.013569	1.871417	9.233056	416
28/12/2003	7.54	6.8228	10326.81	2.020222	1.92027	9.242499	417
04/01/2004	7.56	6.6512	10510.88	2.022871	1.894797	9.260166	418
11/01/2004	7.62	6.524	10577.85	2.030776	1.875488	9.266517	419
18/01/2004	7.64	7.0783	11009.46	2.033398	1.957034	9.30651	420
25/01/2004	7.6	7.1736	11067.02	2.028148	1.970408	9.311725	421
01/02/2004	7.56	7.1008	10849.25	2.022871	1.960207	9.291851	422
08/02/2004	7.52	6.9574	10809.75	2.017566	1.939806	9.288204	423
15/02/2004	7.48	6.7873	10825.36	2.012233	1.915053	9.289647	424
22/02/2004	7.46	6.6237	10983.91	2.009555	1.890654	9.304187	425
29/02/2004	7.58	6.6383	10895.86	2.025513	1.892856	9.296138	426
07/03/2004	7.7	6.7307	11096.55	2.04122	1.906679	9.31439	427
14/03/2004	7.71	6.642	10757.89	2.042518	1.893413	9.283395	428
21/03/2004	7.78	6.6886	10815.99	2.051556	1.900405	9.288781	429
28/03/2004	7.8	6.558	10653.2	2.054124	1.880686	9.273616	430
04/04/2004	7.83	6.3534	10890.61	2.057963	1.84899	9.295656	431
11/04/2004	7.78	6.3611	10846.37	2.051556	1.850201	9.291586	432
18/04/2004	7.77	6.5094	10757.16	2.05027	1.873247	9.283327	433
25/04/2004	7.71	6.648	10639	2.042518	1.894316	9.272282	434
02/05/2004	7.69	6.8372	10385.8	2.039921	1.922378	9.248195	435
09/05/2004	7.69	6.8951	10407.9	2.039921	1.930811	9.25032	436
16/05/2004	7.71	6.9093	9766.72	2.042518	1.932868	9.186736	437
23/05/2004	7.73	6.757	10157.47	2.045109	1.910579	9.225965	438
30/05/2004	7.75	6.6115	10307.22	2.047693	1.888811	9.2406	439
06/06/2004	7.8	6.4721	10191.33	2.054124	1.867501	9.229293	440
13/06/2004	7.84	6.5375	10203.66	2.059239	1.877555	9.230502	441
20/06/2004	7.87	6.5181	10179.44	2.063058	1.874583	9.228125	442
27/06/2004	7.87	6.311	10220.14	2.063058	1.842294	9.232116	443
04/07/2004	7.86	6.2136	10053.47	2.061787	1.82674	9.215673	444
11/07/2004	7.9	6.1306	10044.72	2.066863	1.813293	9.214802	445
18/07/2004	7.9	6.068	10018.07	2.066863	1.803029	9.212146	446
25/07/2004	7.91	6.022	10063.79	2.068128	1.795419	9.216699	447
01/08/2004	7.87	6.2572	10305.89	2.063058	1.833733	9.240471	448
08/08/2004	7.88	6.2639	10227.51	2.064328	1.834803	9.232836	449
15/08/2004	7.2	6.2904	10567.57	1.974081	1.839025	9.265545	450
22/08/2004	7.24	6.5479	10938.15	1.979621	1.879144	9.300012	451
29/08/2004	7.15	6.6641	11163.35	1.967112	1.896735	9.320391	452
05/09/2004	7.13	6.6419	11223.91	1.964311	1.893398	9.325802	453
12/09/2004	7.13	6.6307	11226.82	1.964311	1.89171	9.326061	454
19/09/2004	7.11	6.5521	11513.26	1.961502	1.879786	9.351255	455
26/09/2004	7.1	6.479	11515.07	1.960095	1.868566	9.351412	456
03/10/2004	7.2	6.431	11871.82	1.974081	1.86113	9.381923	457
10/10/2004	7.3	6.5301	12115.36	1.987874	1.876422	9.402229	458
17/10/2004	7.29	6.5532	11834.82	1.986504	1.879953	9.378801	459

	TBT3	USDZAR	ALL	LNTBT3	LNUSDZA	LNALL	T
24/10/2004	7.31	6.2975	11647.15	1.989243	1.840153	9.362817	460
31/10/2004	7.28	6.1748	11655.31	1.985131	1.820476	9.363517	461
07/11/2004	7.27	6.1264	12062.85	1.983756	1.812607	9.397886	462
14/11/2004	7.27	6.1821	12212.87	1.983756	1.821658	9.410246	463
21/11/2004	7.23	6.0302	12337.31	1.978239	1.79678	9.420383	464
28/11/2004	7.2	5.9508	12438.51	1.974081	1.783526	9.428553	465
05/12/2004	7.23	5.8041	12500.26	1.978239	1.758565	9.433505	466
12/12/2004	7.28	5.799	12135.49	1.985131	1.757685	9.403889	467
19/12/2004	7.3	5.746	12389.8	1.987874	1.748504	9.424629	468
26/12/2004	7.32	5.6774	12529.23	1.99061	1.736493	9.43582	469
02/01/2005	7.32	5.6411	12656.86	1.99061	1.730079	9.445955	470
09/01/2005	7.3	5.8812	12714.89	1.987874	1.771761	9.450529	471
16/01/2005	7.29	6.0082	12782.27	1.986504	1.793125	9.455814	472
23/01/2005	7.27	6.051	12497.84	1.983756	1.800224	9.433311	473
30/01/2005	7.24	5.9442	12699.81	1.979621	1.782416	9.449342	474
06/02/2005	7.23	6.0422	13002.21	1.978239	1.798768	9.472875	475
13/02/2005	7.23	6.1957	13085.19	1.978239	1.823856	9.479236	476
20/02/2005	7.21	6.0032	13302.62	1.975469	1.792293	9.495716	477
27/02/2005	7.2	5.8477	13375.55	1.974081	1.766048	9.501184	478
06/03/2005	7.21	5.8722	13634.73	1.975469	1.770229	9.520375	479
13/03/2005	7.2	5.8231	13508.05	1.974081	1.761833	9.511041	480
20/03/2005	7.2	6.0362	13593.17	1.974081	1.797775	9.517323	481
27/03/2005	7.17	6.1721	13191.47	1.969906	1.820039	9.487326	482
03/04/2005	7.17	6.2726	13432.14	1.969906	1.836191	9.505406	483
10/04/2005	7.21	6.1773	13312.88	1.975469	1.820881	9.496487	484
17/04/2005	6.75	6.1823	13075.65	1.909543	1.82169	9.478507	485
24/04/2005	6.71	6.1551	12751.37	1.903599	1.817281	9.453394	486
01/05/2005	6.73	6.0876	12555.96	1.906575	1.806254	9.437951	487
08/05/2005	6.75	6.032	12948.15	1.909543	1.797079	9.468708	488
15/05/2005	6.75	6.1895	12954.15	1.909543	1.822854	9.469171	489
22/05/2005	6.75	6.4003	13418.33	1.909543	1.856345	9.504377	490
29/05/2005	6.76	6.5502	13770.34	1.911023	1.879496	9.530272	491
05/06/2005	6.75	6.772	14020.86	1.909543	1.912796	9.548301	492
12/06/2005	6.76	6.7273	14029.06	1.911023	1.906174	9.548886	493
19/06/2005	6.76	6.7922	14326.59	1.911023	1.915775	9.569873	494
26/06/2005	6.76	6.7123	14103.92	1.911023	1.903942	9.554208	495
03/07/2005	6.75	6.6669	14244.13	1.909543	1.897155	9.5641	496
10/07/2005	6.74	6.8349	14457.8	1.90806	1.922042	9.578989	497
17/07/2005	6.72	6.6408	14720.93	1.905088	1.893232	9.597026	498
24/07/2005	6.73	6.6151	15023.56	1.906575	1.889355	9.617375	499
31/07/2005	6.73	6.6322	15143.64	1.906575	1.891937	9.625336	500
07/08/2005	6.72	6.4748	15464.37	1.905088	1.867918	9.646294	501
14/08/2005	6.72	6.3844	15775.9	1.905088	1.853858	9.666239	502
21/08/2005	6.72	6.4548	15625.59	1.905088	1.864824	9.656665	503
28/08/2005	6.71	6.4645	15298.74	1.903599	1.866326	9.635526	504
04/09/2005	6.72	6.3956	15766.35	1.905088	1.85561	9.665633	505
11/09/2005	6.74	6.2808	15890.19	1.90806	1.837497	9.673457	506
18/09/2005	6.74	6.352	16372.93	1.90806	1.84877	9.703385	507
25/09/2005	6.75	6.3636	16140.45	1.909543	1.850594	9.689084	508
02/10/2005	6.79	6.3789	16875.65	1.915451	1.852996	9.733627	509
09/10/2005	6.79	6.4614	16136.26	1.915451	1.865846	9.688824	510

	TBT3	USDZAR	ALL	LNTBT3	LNUSDZA	LNALL	T
16/10/2005	6.79	6.5462	15661.79	1.915451	1.878885	9.658979	511
23/10/2005	6.78	6.5588	15616.02	1.913977	1.880808	9.656053	512
30/10/2005	6.84	6.6394	16237.19	1.922788	1.893022	9.69506	513
06/11/2005	6.85	6.6428	16881.88	1.924249	1.893534	9.733996	514
13/11/2005	6.86	6.729	17107.54	1.925707	1.906427	9.747275	515
20/11/2005	6.97	6.7237	17468.97	1.941615	1.905639	9.768181	516
27/11/2005	6.89	6.5627	17318.27	1.930071	1.881402	9.759517	517
04/12/2005	6.87	6.4489	16940.83	1.927164	1.86391	9.737482	518
11/12/2005	6.82	6.315	17393.99	1.919859	1.842928	9.76388	519
18/12/2005	6.8	6.316	17658.29	1.916923	1.843086	9.778961	520
25/12/2005	6.78	6.3504	18123.93	1.913977	1.848518	9.804988	521
01/01/2006	6.78	6.3206	18096.54	1.913977	1.843814	9.803476	522
08/01/2006	6.77	6.1709	18414.85	1.912501	1.819845	9.820913	523
15/01/2006	6.73	6.0443	18567.64	1.906575	1.799116	9.829176	524
22/01/2006	6.72	5.99	18880.43	1.905088	1.790091	9.845881	525
29/01/2006	6.69	6.0232	19718.47	1.900614	1.795619	9.889311	526
05/02/2006	6.69	6.0834	19505.99	1.900614	1.805564	9.878477	527
12/02/2006	6.71	6.1281	19395.08	1.903599	1.812885	9.872775	528
19/02/2006	6.68	6.0864	19389.32	1.899118	1.806057	9.872478	529
26/02/2006	6.59	6.0505	19486.12	1.885553	1.800141	9.877458	530
05/03/2006	6.52	6.135	19299.56	1.874874	1.81401	9.867838	531
12/03/2006	6.56	6.249	18753.05	1.880991	1.832421	9.839112	532
19/03/2006	6.49	6.2008	19820.67	1.870263	1.824678	9.894481	533
26/03/2006	6.51	6.2712	20320.49	1.873339	1.835968	9.919385	534
02/04/2006	6.6	6.2285	20351.74	1.88707	1.829136	9.920922	535
09/04/2006	6.62	6.0566	20599.91	1.890095	1.801149	9.933042	536
16/04/2006	6.64	6.1101	20666.97	1.893112	1.809943	9.936292	537
23/04/2006	6.7	6.0036	21029.02	1.902108	1.792359	9.953659	538
30/04/2006	6.74	6.0556	21135.51	1.90806	1.800983	9.95871	539
07/05/2006	6.77	6.0269	21822.24	1.912501	1.796233	9.990685	540
14/05/2006	6.82	6.062	21781.46	1.919859	1.80204	9.988814	541
21/05/2006	6.83	6.3826	20199.75	1.921325	1.853576	9.913426	542
28/05/2006	6.83	6.5545	20696.16	1.921325	1.880152	9.937703	543
04/06/2006	6.82	6.6069	20874.86	1.919859	1.888115	9.946301	544
11/06/2006	7.26	6.6963	19324.72	1.98238	1.901555	9.86914	545
18/06/2006	7.18	6.7981	19698.94	1.971299	1.916643	9.88832	546
25/06/2006	7.23	7.1356	20499.83	1.978239	1.965096	9.928172	547
02/07/2006	7.19	7.259	21237.87	1.972691	1.982242	9.963541	548
09/07/2006	7.16	7.1028	21358.31	1.96851	1.960489	9.969196	549
16/07/2006	7.14	7.1352	20676.2	1.965713	1.96504	9.936739	550
23/07/2006	7.43	7.0975	20179.65	2.005526	1.959743	9.91243	551
30/07/2006	7.63	6.9438	20732.41	2.032088	1.937849	9.939453	552

