



UNIVERSITY *of the*
WESTERN CAPE

FACULTY OF ECONOMIC AND MANAGEMENT SCIENCES

DEPARTMENT OF ECONOMICS

Internal Versus External Reasons for the Rand-Dollar Exchange Rate

Volatility

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A mini-thesis submitted in partial fulfilment of the requirements for the degree of Master of Commerce (Economics) in the Department of Economics, University of the Western Cape.

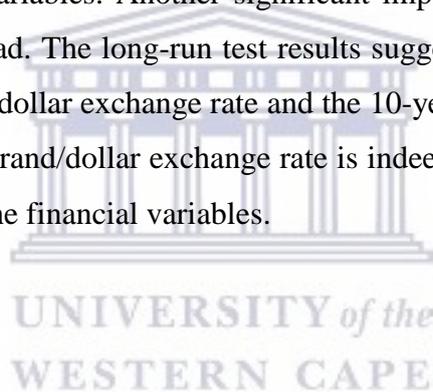
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ABSTRACT

Increased exchange rate volatility is an impediment to the health of the economy of a country. Following the 1995 policy shift made by the South African Reserve Bank, from a fixed exchange rate regime to a free floating exchange rate regime; the rand/dollar exchange rate became volatile. The aim of the study was to investigate the forces that lead the exchange rate volatility. In more details, the study looked at the relationship between the rand/dollar exchange rate and its determinants. In terms of the methodology, a Structural Vector Autoregressive (SVAR) model was used to analyse the relationship between the rand/dollar exchange rate and its determinants.

In the short run, the impulse response function results showed that there were no strong bi-directional relationships between the rand/dollar and its determinants between 1995 and 2014. The only significant relationship, in the short run, was found to be between the exchange rate and nominal variables. Another significant impact was that of the exchange rate on the 10-year bond spread. The long-run test results suggested that there is a unilateral relationship between the rand/dollar exchange rate and the 10-year bond spread. The long-run tests results indicated that the rand/dollar exchange rate is indeed an 'equity' currency, and is mostly driven by changes in the financial variables.



KEYWORDS

Exchange rate, Exchange rate determination, Rand/Dollar, Floating exchange rate regime, Volatility, Monetary models, South Africa.

DECLARATION

I, Eunice Ishimwe Mariella TWAHIRWA, hereby declare that this mini-thesis entitled '*Internal Versus External Reasons for the Rand-Dollar Exchange Rate Volatility*' is an end product of my own work under the supervision of Mr. Dawie van Lill, and that it has not been previously submitted in part or in its entirety for any degree or examination in any other university. All the sources I have used or quoted have been indicated and acknowledged by means of complete references.

Signature:

Date:



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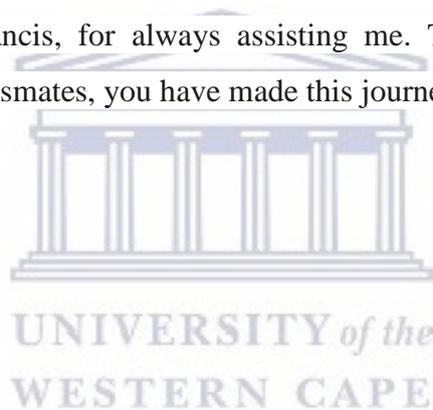
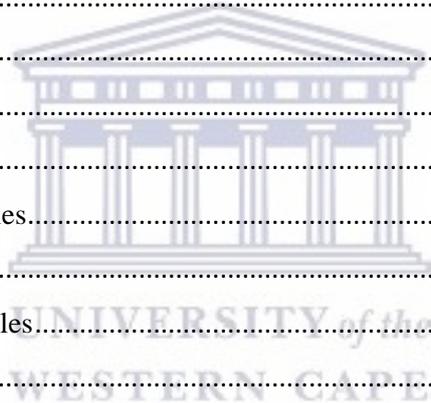


TABLE OF CONTENTS

ABSTRACT.....	i
KEYWORDS.....	i
DECLARATION	ii
ACKNOWLEDGEMENTS.....	iii
LIST OF FIGURES.....	vii
LIST OF TABLES.....	viii
LIST OF ABBREVIATIONS	ix
Chapter One.....	1
1. Introduction	1
1.1 Background.....	1
1.2 Rationale	1
1.3 Research objectives.....	2
1.4 Preliminary literature review	2
1.5 Data and methodology	3
1.6 Ethics	3
1.7 Structure of the study	3
Chapter Two.....	5
2. Literature Review	5
2.1 Introduction.....	5
2.2 Important Concepts and Historical Background.....	6
2.2.1 Exchange rate: important concepts	6
2.2.2 The Rand/Dollar Exchange Rate Historical Background	7
2.3 Theoretical Literature.....	10
2.3.1 Determinants of the Exchange Rate: Theoretical Models.....	10
2.4. Empirical Evidence.....	19
2.4.1 Developed countries.....	19
2.4.2 Developing and emerging countries.....	20
2.4.3 South Africa.....	21
2.5. Conclusion	23
Chapter Three	25
3. Methodology.....	25
3.1. Introduction.....	25

3.2. Data.....	25
3.2.1. Data sources.....	25
3.2.2. Variables.....	26
3.3. Model specification.....	33
3.3.1. Model identification and restrictions.....	33
3.3.2. Vector Autoregression Models.....	36
3.4. Cointegration.....	38
3.4.1. Stationarity process: unit root test.....	38
3.4.2. Johansen Test.....	41
3.4.3. Vector Error Correction Model.....	42
3.5 Diagnostic checks.....	43
3.6 Conclusion.....	45
Chapter Four.....	47
4. Results.....	47
4.1 Introduction.....	47
4.2. Unit Root Test.....	47
4.3. Impulse Response.....	49
4.3.1 Nominal sector variables.....	50
4.3.2 Real sector variables.....	53
4.3.3 Financial sector variables.....	53
4.3.4 News variable.....	55
4.4 Cointegration Test Results.....	57
4.4.1 Lag length structure.....	57
4.4.2 Johansen Test Results.....	58
4.4.3 Vector Error Correction Model Results.....	59
4.4.4 Granger Causality and Variance Decomposition.....	62
4.5 Diagnostic Check Results.....	64
4.5.1 Autocorrelation LM Test.....	64
4.5.2 Heteroscedasticity Test.....	65
4.5.3 Normality Test.....	65
4.5.4. Model stability.....	66
4.6 Conclusion.....	67
Chapter Five.....	69
5. Conclusion.....	69



5.1 Introduction.....	69
5.2. Findings.....	70
5.2.1 Short-Run Dynamics.....	70
5.2.2 Long-Run Dynamics.....	70
5.3 Limitations of the Study.....	70
5.4 Further Research.....	71
Reference List.....	72



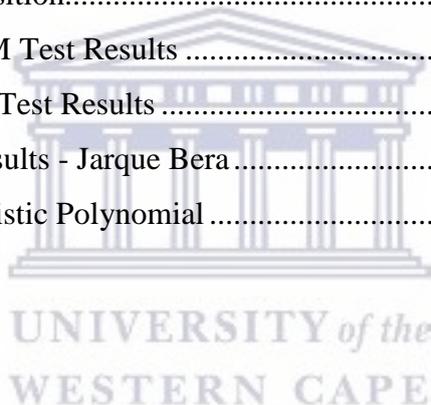
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LIST OF FIGURES

Figure 2.1 Rand/US\$ Dollar Exchange Rate Policy Changes (1960-2014)	7
Figure 3.1 The Rand per US Dollar Exchange Rate (January 1995-December2014)	26
Figure 3.2 South African Prime Rate and Federal Reserve Rate (January 1995-December 2014)	27
Figure 3.3 Industrial Production Index South Africa and United States (January 1995-December2014)	29
Figure 3.4 Consumer Price Index South Africa and United States (January1995-December2014)	30
Figure 3.5: Total Share Index- South Africa (January1995-December2014)	31
Figure 3. 6: Ten-Year Bond rate South Africa and United States (January 1995-December 2014)	31
Figure 3.7 Volatility Index- United States (January 1995- December 2014)	32
Figure 3.8 Stationary variable	39
Figure 3.9 Non-stationary variable	39
Figure 4.1 Monetary Policy	50
Figure 4.2 Inflation	51
Figure 4.3 Industrial Production	53
Figure 4.4 10year Bond (T-Bill) Spread	54
Figure 4.5 Total Shares Index	54
Figure 4.6 News Variable	56
Figure 4.7 Inverse Roots of AR Characteristic Polynomial	66

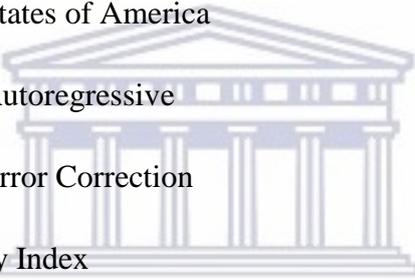
LIST OF TABLES

Table 4.1 Stationarity Test - South Africa	47
Table 4.2 Stationarity test - USA	48
Table 4.3 Stationarity test for the sticky price model variables.....	49
Table 4.4 Lag Length Structure	57
Table 4.5 Trace and Maximum Eigenvalue Tests	Error! Bookmark not defined.
Table 4.6 Vector Error Correction Model- Short Run($r=2$).....	59
Table 4.7 Vector Error Correction Model - Long Run($r=2$).....	60
Table 4.8 Vector Error Correction Model - Short run ($r=1$).....	61
Table 4.9 Vector Error Correction Model- Long Run ($r=1$).....	61
Table 4.10 Granger-Causality	62
Table 4.11 Variance Decomposition.....	62
Table 4.12 Autocorrelation LM Test Results	64
Table 4.13 Heteroscedasticity Test Results	65
Table 4.14 Normality Test Results - Jarque Bera	65
Table 4.15 Roots of Characteristic Polynomial	67



LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
FRED	Louisiana Federal Reserve Bank Statistics Database
IFS	International Monetary Fund Statistics Database
SARB	South African Reserve Bank
SIC	Schwarz Information Criterion
SVAR	Structural Vector Autoregressive
SA	South Africa
USA	United States of America
VAR	Vector Autoregressive
VEC	Vector Error Correction
VIX	Volatility Index



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Chapter One

1. Introduction

1.1 Background

South Africa has had three different exchange rate policies since the early 1980s. From 1985 to 1995 the country had a dual exchange rate regime with a commercial and a financial rand. This was followed by a controlled floating exchange rate from 1995 to 1999, and a free floating exchange rate from 1999 onwards (Gossel & Biekpe, 2012: 108). Since the adoption of the floating exchange rate in 1995 the rand has been very volatile.

According to Aron and Elbadawi (1999: 2) large fluctuations in the rand/dollar exchange rate started in February 1996 and continued until November 1997. Reasons for the depreciation include the uncertainty around economic policies and the fall in the price of gold and other minerals. According to the authors the sources of the volatility were both internal and external. The external determinant of volatility was due to the subsequent reduced investor confidence in emerging countries financial markets, caused by the Asian crisis; while internal determinants were poor economic growth and the widening current account deficit (Aron & Elbadawi, 1999: 2).

Further fluctuations occurred once again in the early 2000s when the rand unexpectedly fell by 42% against the US dollar in the fourth quarter of 2001 (Bhundia & Gottschalk, 2003: 3). Bhundia and Gottschalk (2003: 4) provide the main reasons for the 2001 Rand/Dollar depreciation. The first reason was the sluggish global economic growth during that time. Secondly, investors risk aversion led to a depreciation of most emerging countries currencies against the US dollar. Thirdly, local factors included widened current and financial account deficits. Based on the arguments of Bhundia and Gottschalk (2003) this particular study aims to establish whether the cited sources of fluctuations had a similar impact on the Rand/Dollar, from 1995 to 2014.

1.2 Rationale

One of the main factors necessary for economic stability is a stable exchange rate. A very volatile exchange rate is a hindrance to economic stability; as it generates fluctuations in the prices of tradable goods, stocks and bonds. Additionally, a frequently unstable exchange rate inflates the sovereign debt payments and decreases domestic purchasing power (Diebold &

Nerlove, 1989: 2). Lower purchasing power translates into an increase in domestic prices, which results in output and income reduction. The lower output and income in turn aggravate the burden of unemployment. A persistently volatile rand/dollar exchange rate does not only dampen investors' confidence, but it also worsens existing socio-economic issues in the affected country (i.e. non-ending wage demonstrations causing social unrest).

This study aims to identify whether the volatility of the rand/dollar is caused by local factors (changes in the economic or policy events in South Africa) and/or external factors (changes in economic or policy events in the USA). Therefore the objective of the paper is to study the relationship between the rand/dollar exchange rate and its determinants.

1.3 Research objectives

The aim of this study is to identify the sources of the rand/dollar exchange rate volatility. Specifically the study will focus on the period from 1995 to 2014. The chosen starting period of the analysis is 1995, because fluctuations in the rand/dollar increased in that year following the adoption of the floating regime.

1.4 Preliminary literature review

According to Gossel and Biekpe (2012: 112), the determinants of the rand/dollar exchange rate changed after 1995. Determinants give a possible indication of the source of volatility. Prior to 1995 changes in the dollar price of gold and other minerals, as well as the political risk index, drove the movements in the rand/dollar exchange rate. After 1995 only the difference in share purchases between foreigners and locals, as well as the difference in the long-term interest rate, impacted significantly on the movements in the rand/exchange rate (Gossel & Biekpe, 2012: 112; Frankel, 2007: 9). Therefore the rand has moved from being a "commodity currency" to being an "equity currency".

Bhundia and Gottschalk (2003: 5) provide a theoretical background arguing that the rand/dollar fluctuations can be determined by demand/supply and nominal shocks. They further stress that the demand and supply shocks, such as an increase in government spending or an increase in productivity, impact on the exchange rate in the long-run. Nominal shocks, such as a change in monetary policy, impact on the exchange rate only in the short run. The authors found that the reason for the 2001 depreciation, in the long run, was the financial market developments (i.e. risk aversion/speculation). Bhundia and Gottschalk (2003: 5)

concluded that, in the short run, domestic nominal shocks are what caused rand/dollar fluctuations.

As established by Bhundia and Gottschalk financial market developments such as news affect the rand/dollar exchange rate. In their study Fedderke and Flamand (2005: 7) found that only macroeconomic news from the United States of America, on the real or nominal side of the economy, had an impact on the rand/dollar exchange rate. The authors also found that good news from both countries had an impact on the rand/dollar exchange rate, with the impact of news from the United States of America dominating the impact of news from South Africa (Fedderke & Flamand, 2005: 12). In the light of Fedderke and Flamand's (2005) findings the study will investigate the role of external and internal news as a source of the Rand/Dollar exchange rate volatility.

1.5 Data and methodology

The study will use quantitative methods to build statistical inferences about the determinants of the rand/dollar fluctuations. The data used to study the relationship between the rand/dollar exchange rate and its determinants will be monthly data. The period considered starts for the study begins in January 1995 and continues until December 2014. The data sources for both countries are the South African Reserve Bank, the International Monetary Fund (IFS) and the Federal Reserve Bank of St. Louis (FRED) statistics databases.

The study will use a Structural Vector Autoregressive (SVAR) model. A SVAR model allows inferences to be drawn from theoretical fundamentals (Stock & Watson, 2001: 4). Since the Sticky-Prices model is used as a premise to analyse the dynamics between the rand/dollar and its determinants, a SVAR is the most appropriate model to use for the study.

1.6 Ethics

The study will use aggregated official and other publicly available data and therefore there is no possibility that ethical standards will be compromised.

1.7 Structure of the study

The paper is divided into five chapters. Theoretical frameworks and empirical findings on exchange rate determination are discussed in the second chapter. A description of the econometric analysis will be provided in the third chapter. The fourth chapter will consist of results and inferences about the relationship between the rand/dollar exchange rate and its

determinants. The last chapter will offer some conclusion and provide a summary of the study.



Chapter Two

2. Literature Review

2.1 Introduction

A volatile exchange rate creates microeconomic and macroeconomic instability, and generates undesirable speculation in the financial market (Diebold & Nerlove, 1989: 2). The microeconomic instability stems from exchange rate fluctuations that increase domestic prices, and reduce domestic purchasing power and consumption. The decrease in purchasing power and consumption would in effect mean that firms are overproducing. Overproduction would require these firms to reduce their output and possibly retrench workers; in order to remain operational. In terms of macroeconomic instability, an unstable exchange rate distorts import and export prices, increases unemployment, inflates government debt payments and slows down economic growth (Diebold & Nerlove: 1989: 2).

Furthermore, when the exchange rate is not fairly stable, harmful speculations emerge in the financial market which make investors risk averse towards domestic assets and result in capital flights (Ogun, 2012: 518). Given all these negative shocks which are created by a volatile exchange rate, it is important to analyse the determinants of the exchange rate. Understanding what determines the exchange rate can, in turn, assist in countering any negative exchange rate volatility. This chapter will review the theoretical and empirical literature on the determinants of the exchange rate. The numerous theoretical models to be discussed indicate that the determinants of the exchange rate are also the sources of the exchange rate volatility. Although most of these models concur that shocks in the real and monetary sectors as well as financial developments are the main determinants and sources of exchange rate volatility, they differ regarding the dynamics and the end results emanating from these relationships.

The rest of the chapter is structured as follows. Section 2.2 provides historical background aimed at giving the events a contextual framework. Section 2.3 provides a theoretical overview of the different models explaining what determines the exchange rate and the kind of end result that comes from these relationships. The last section, Section 2.4 consists of a review of the empirical evidence relevant to the determinants of exchange rate volatility in the case of developed, as well as emerging countries, with a specific focus on South Africa.

2.2 Important Concepts and Historical Background

2.2.1 Exchange rate: important concepts

Abel, Bernanke and Croushore (2011: 474) define the nominal exchange rate between two currencies as “the number of units of a foreign currency that can be purchased with one unit of the domestic currency”. Usually, the nominal exchange rate, often abbreviated as the exchange rate is the ‘price’ at which two currencies can be traded as ‘goods’ in the foreign exchange market. The foreign exchange market (forex market) is the market where different currencies are traded internationally.

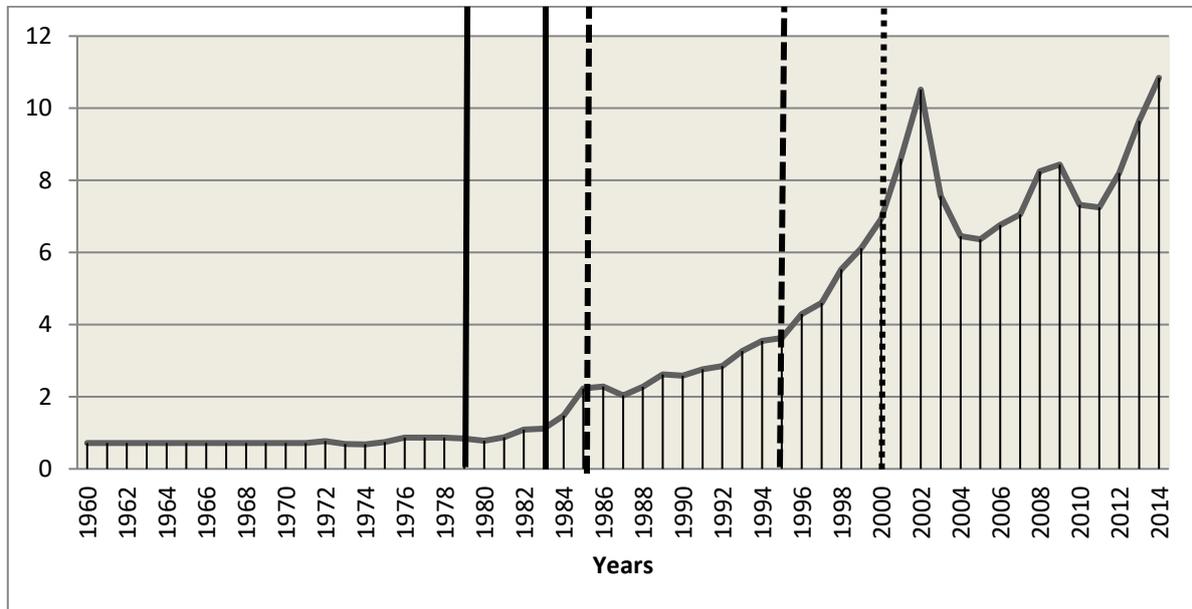
In the forex market, when the exchange rate is, for example, 10 rand to the dollar, in nominal terms this means that it requires a buyer to pay 10 rand in order to buy one US dollar. If the value of the rand increases relative to the dollar such that it requires only 6 rand to buy one dollar, the rand is said to have appreciated. In the opposite case, if the value of the rand has weakened relative to the dollar, for instance, requiring 15 rand to buy 1 dollar, the rand is said to have depreciated (Abel, Bernanke & Croushore, 2011: 474).

Lastly, there are different types of exchange rate systems; the study considers two prominent systems: the fixed exchange rate system and the floating exchange rate system. In a fixed exchange rate system, it is the central bank’s responsibility to determine the levels of the home currency against other currencies; whilst in a floating exchange rate system, the forces of demand and supply in the forex market determine the rate (Abel, Bernanke & Croushore, 2011: 618).

2.2.2 The Rand/Dollar Exchange Rate Historical Background

As presented in Figure 2.1, South Africa adopted five different exchange rate policies, from 1979 to 2014.

Figure 2.1 Rand/US\$ Dollar Exchange Rate Policy Changes (1960-2014)



Sichei, Gebreselasie and Akanbi (2005: 1-2) identified four of these changes in the exchange rate policy. The first change occurred in 1979 when a fixed exchange rate system was replaced by a dual exchange rate system. The dual exchange rate system comprises two foreign exchange market (forex) transactions dealing with the 'commercial rand' (transactions related to goods and services) and the 'financial rand' (transactions related to international capital movements) (Sichei, Gebreselasie & Akanbi, 2005: 2). The second policy change occurred in 1983 when the Central Bank abolished the 'financial rand' to halt capital flights. In 1985, the 'financial rand' was reinstated until 1995 (Frankel, 2007: 9). The exchange rate policy was changed again to a managed floating exchange rate system in March 1995, when the Central Bank's intervention was restricted only to reducing short-term fluctuations in the exchange rate (Sichei, Gebreselasie & Akanbi, 2005: 2, Gossel & Biekpe, 2012: 108). The last change occurred in 2000, as discussed by Duncan and Liu (2009: 379), because defending the rand became too costly. The South African Reserve Bank decided to move to a free-floating exchange rate system. Table 2.1 provides a summary of the different exchange rate regimes the South African Reserve Bank adopted from the 1960s to present.

Table 2.1 South African Reserve Bank Exchange Rate Regimes Changes (1961-present)

Dates	Policy Changes
1961-1979	Fixed Exchange Rate Regime
1979-1983	Dual Exchange Rate Regime: Crawling Peg Commercial Rand and Free-Floating Financial Rand
1983-1985	Managed Float Exchange Rate
1985-1995	Dual Exchange Rate Regime: Managed Float Commercial Rand and Free Float Financial Rand
1995-2000	Managed Float Exchange Rate
2000-present	Free-Floating Exchange Rate

In a free-floating exchange rate system, exchange rates are determined by supply and demand forces in the forex market and are very sensitive to economic and political news (Abel, Bernanke & Croushore, 2011: 474). Although the free-floating exchange rate makes it easier for the economy to respond to external and internal shocks, the system makes the exchange rate volatile (Arratibel, Furceri, Martin & Zdezienicka, 2011: 262).

When South Africa adopted different exchange rate systems in 1979, some of the determinants of the rand/dollar exchange rate changed as well. According to Gossel and Biekpe (2012: 112), prior to 1995, the rand was a 'commodity currency'; whilst after 1995 it became an 'equity currency'.¹ According to the authors, before 1995 the rand/dollar exchange rate was mostly driven by the net equity and bond purchases by foreigners, and the long-term interest rate differentials, and it was heavily driven by the dollar price of gold. They further argue that after 1995 the rand/dollar exchange rate was mainly driven by the net purchase of equity by international investors and the long-term interest differentials, and the

¹ A commodity currency is one that is primarily driven by the market forces in the commodity market, whilst an equity currency is primarily driven by the market forces in the stock market (Gossel & Biekpe: 2012: 112).

price of commodities playing no role in rand/dollar exchange rate determination (Gossel & Biekpe, 2012: 112). Gossel and Biekpe (2012) point out that ultimately the financial market developments and interest differentials between South Africa and the US determine the demand and supply of rands and dollars in the South African forex market. These two determinants govern the trajectory of the rand/dollar exchange rate. Consequently, any changes in the determinants of the rand/dollar exchange rate lead to a change in the exchange rate.

Since the adoption of the floating exchange rate system in South Africa, it seems the volatility of the Rand/Dollar exchange rate has increased. Aron and Elbadawi (1999: 2) established that the rand exhibited volatility in February 1996 as a result of the macroeconomic instability, investors' speculation, uncertainty concerning the new government's policy package, and massive short-term capital inflows which exposed the economy to possibilities of capital flow reversals. These shocks persisted and were aggravated in late 1997 because of the Asian crisis and global risk aversion (Aron & Elbadawi, 1999: 2). This risk aversion and the contagion from the Asian crisis translated into a reduction in gross national output and lower equity returns. This drop in economic and financial fundamentals led to fluctuations in the rand/dollar exchange rate which, in turn, made the rand volatile against the dollar.

Similar to Aron and Elbadawi (1999), Bhundia and Gottschalk (2003: 3) argue that four factors led to this substantial depreciation in the value of the rand against the dollar in 2011. Three factors that contributed to the depreciation and increased volatility of the rand were due to a minor recession in the USA, a growing current account and financial account deficit, and contagion from the Argentinian currency crisis. The fourth and main factor was financial market developments driven by speculation or investors mostly favouring short term assets (Bhundia & Gottschalk, 2003: 3). However, financial market developments and speculation have not been the only cause of the rand depreciation and volatility. For instance, the rand value appreciated by 6% against the dollar in 2004; this might have been the result of the role of news in the financial market (Fedderke & Flamand, 2005: 3). Fedderke and Flamand (2005) argue that news from the USA and the ways in which investors disseminate information largely drive the rand/dollar exchange rate.

2.3 Theoretical Literature

2.3.1 Determinants of the Exchange Rate: Theoretical Models

This section provides an overview of the different theoretical models on exchange rate dynamics and determination. The theoretical models are discussed chronologically: from the oldest model to the most recent.

2.3.1.1 The Classical Monetary Approach: Purchasing Power Parity Model

The classical monetary model is the first model developed for analysing exchange rate dynamics. The purchasing power parity model is based on the premise that, in equilibrium, the exchange rate equals to the ratio of the domestic to foreign prices (Frenkel, 1976: 69). According to Frenkel (1976: 71), prices and exchange rates are endogenous variables and are determined simultaneously. Therefore, as the money market clears the exchange rate is fixed where the purchasing power of the different currencies is of equal value. In terms of dynamics, considering an increase in the domestic money supply, there would be an upward pressure on the domestic price level relative to the foreign price level, and the exchange rate is supposed to depreciate in order to maintain equilibrium (Pentecost, 1993: 25).

The classical monetary model for exchange rate determination has been discredited for the weakness of its assumptions in terms of empirical validity. In the real world policy interventions, capital restrictions and risk differentials prove the assumption of a perfect market to be false. Hence the relationship between the domestic and foreign prices, as described in the classical model, cannot be validated empirically.

2.3.1.2 The Keynesian IS-LM Model

Following the classical model of exchange rate determination was the Keynesian view of how the exchange rate is determined. In this model the exchange rate is no longer only determined by the relationship between domestic and foreign prices. More variables affect the demand and supply of the exchange rate such as the trade flows of goods and services (imports and exports), domestic and foreign interest rate differentials, and domestic and foreign income.

As Abel, Bernanke and Croushore (2011: 488) argue, in the IS-LM model, the exchange rate has three determinants. They determinants are the domestic/foreign income level, the domestic/foreign nominal interest rate and the demand for domestic/foreign goods. To

illustrate, firstly, a rise in domestic income leads to an increase in imports, which translates into an increase in the demand for foreign currencies and an excess supply of the domestic currency, and thus the domestic currency depreciates (Abel, Bernanke & Croushore, 2011: 488).

Secondly, an increase in the foreign interest rate makes the foreign assets more attractive relative to the domestic assets, which increases the supply of the domestic currency relative to its demand, resulting in an excess supply of the domestic currency and consequently the exchange rate depreciates. Lastly, a rise in foreign demand for domestic goods leads to a higher demand for domestic goods, which implies that there is an increase in the demand for the domestic currency. The increase in the demand for domestic currency leads to the exchange rate appreciating (Abel, Bernanke & Croushore, 2011: 488).

The IS-LM model also has shortcomings such as lack of relevance to the real world. It is only a description of short-term exchange rate dynamics. Pentecost (1993) argue that the Keynesian approach excluded current important determinants of the exchange rate, such as expectations and speculation in the forex market are not included in the model.

2.3.1.3 The Monetary Models: Flexible Prices and Sticky Prices Models

The advent of the monetary models brought additional information to the current models at that time (i.e.: IS-LM and classical monetary models). The new exchange rate determinants introduced, in the models, are money held as an asset, bonds and expectations (Isard, 1995: 118-119).

As Isard (1995: 118-119) asserts, monetary models are based on two behavioural conditions of the demand for money and four equilibrium conditions. The two conditions for the demand for money are that, one, the domestic and foreign demand for money are similar and with common elasticities, and two, the domestic demand for money has a positive relationship with the domestic income and has a negative relationship with the nominal domestic interest rate.

Gardeazabal and Regulez (1992: 8-12) discuss the four restrictions on the monetary models for exchange rate determination. First, the domestic money supply must equal the money demand (the same as the foreign money supply and demand). Second, the domestic and foreign bonds should be substitutable. Third, the domestic and foreign currency should have the same purchasing power that is purchasing power parity must hold). Lastly, the expected

depreciation of the national currency must be less than the domestic to foreign interest rate differential, in other words, uncovered interest rate parity must hold; such that the domestic interest rate should be greater than the foreign interest rate, to cover for the loss incurred should the domestic currency depreciate (Gardeazabal & Regúlez, 1992: 8-12).

There are two monetary models for exchange rate determination. The first model is the flexible price model which was proposed by Frenkel and Benson (1976) (Gardeazabal & Regúlez, 1992: 7). The model refers to the exchange rate as the (expected) relative price of a unit(s) of a currency in exchange for a unit(s) of another currency (Gardeazabal & Regúlez: 1992: 7). According to Frankel (1983: 87), in the flexible exchange rate model, the exchange rate is determined by the domestic and foreign demand for money, the real income level, the price level and the nominal interest rate.

In the model, a rise in the domestic money supply relative to the foreign money supply leads to the domestic currency depreciating against the foreign currency (Frankel, 1983: 87-88). A rise in domestic real income leads to an increase in the demand for the domestic currency and thus an appreciation of the domestic currency. Likewise, if the domestic price of the foreign currency is expected to fall relative to the value of the domestic currency, then the value of the domestic currency remains higher which translates into an appreciation of the domestic currency. Thus in the flexible price model the prices react to any change in the determinants and so does the exchange rate.

The second model is the sticky price model which was developed by Dornbusch (1976), Frankel (1979) and extended by Hooper and Morton (1982) to form the sticky price-asset monetary model (Taylor, 1995: 23). This model is built on the uncovered interest rate parity assumption which relies on the short-run equilibrium condition stating that the expected change in the exchange rate should equal the change in the interest rate differential between two countries (Taylor, 1995: 23).

Additionally, as explained by Taylor (1995: 23-24) , and echoed by Pentecost (1993: 62-63), and Gardeazabal and Regulez (1992: 13), the sticky price model allows for short-term exchange rate disequilibrium since different markets clear at different times. Furthermore, because of the existence of contracts and imperfect information, as well as a delay in changes of consumer habit, prices are expected to adjust slowly in the sticky price model (Frankel, 1983: 89). The difference between the two monetary models lies in the price and exchange

rate adjustments after a shock; in the flexible price model prices and the exchange rate adjust immediately while in the sticky price model the prices and the exchange rate adjust slowly.

The main determinants of the exchange rate in the sticky price model, as developed by Hooper and Morton (1980: 6), are the domestic money supply, the domestic price level relative to the foreign price level, the level of output in both countries, the interest rate differential between the domestic and foreign country, and the expected rate of change in the exchange rate (Hooper & Morton, 1980: 6). According to Afat, Gómez-Puig and Sosvilla-Rivero (2015: 7), the main assumption of the sticky price model is that there are short-term deviations of the exchange rate, as a result of legal barriers to commerce, tariffs and differences in the components of price indices of different countries. Therefore, when there is a shock in the interest rate, the asset market adjusts rapidly while the goods market adjusts slowly; this leads to the overshooting of the exchange rate in the short run (Afat, Gómez-Puig & Sosvilla-Rivero, 2015: 7).

In terms of dynamics, assume an increase in the domestic money supply. As Taylor (1995: 23-24) and Isard (1995: 121-123) illustrate, consider an economy in equilibrium, with all the determinants in a steady state, and the domestic central bank unexpectedly announces a permanent increase in money supply. In the short term, domestic interest will decline, the price level will increase by the same amount as the money supply and the exchange rate will depreciate below the long-term level. As the gap between the domestic and foreign interest rate widens, there will be capital outflows which will, in turn, push the exchange rate below its expected long-term level. However, the depreciated currency and low domestic interest rate will spur production and exports, and prices will slowly rise (Isard, 1995: 121-123). As exports increase, more domestic currency will be demanded which will lead to the domestic currency appreciating (Hooper & Morton, 1980: 6; Taylor, 1993: 24). For the case of the rand/dollar exchange rate, the sticky price model to exchange rate modelling and determination is the most appropriate. The reason is that the rand was initially managed under the managed floating rate from 1995 to 2000; which made currency prices sticky (not flexible) in the forex market (Sichei, Gebreselasie & Akanbi, 2005: 4).

Furthermore, the South African Reserve Bank uses an inflation targeting monetary framework which was found to have an implication for exchange rate movements (Li, 2011: 428). Mtonga (2011: 33) attests to the findings of Li (2011), arguing that ever since the switch in monetary regimes in 2000; the significance and magnitude of the impact of

fundamentals (i.e. monetary policy instruments) on the rand amplified. Li (2011: 428) further asserts that the currency of a country implementing inflation targeting is expected to have a higher correlation with an influential currency like the US dollar during joint appreciation than joint depreciation. The author further ascertained that the increasing or decreasing interest rate differentials lowers exchange rate correlation; hence the uncovered interest parity condition, which serves as a fundamental assumption for the sticky price model, is consistent with the empirical evidence (Li, 2011: 428).

Isard (1995: 124) and Pentecost (1993: 70-71) identify a few problems in the monetary models. The main problem is the fact that empirically, the model is not justified since variables such as money supply and the interest rate can be manipulated simultaneously or individually. This lack of empirical justification makes the empirical evidence about exchange rate relationships diverge from the economic theory.

Afat, Gómez-Puig and Sosvilla-Rivero (2015: 8-9) also argue that monetary models have two main shortcomings. The first shortcoming is that the money demand assumption overlooks the role of reserve currencies in the determination of exchange rate movements. The authors point out that the demand of certain currencies such as the US dollar is not merely driven by the demand in the forex market. The demand for such a currency is determined by international capital and goods transaction, and the large amount kept by Central Banks as foreign reserves. Therefore, the amount of money supply does not equal the amount of money demanded in the money market equilibrium; this is because not all agents in this market are controlled for. The second shortcoming is that, given changes in income and interest rate, the elasticity of money demand is not stable and constant, especially during financial crises, financial developments and regulatory changes. Hence, the elasticity of money demand changes according to different factors which are not captured in the model (Afat, Gómez-Puig & Sosvilla-Rivero, 2015: 8-9). Amongst other problems are the difficulty in underpinning the effect of the money demand, a clear process that describes the impact of a change in the current account of the exchange rate (Isard, 1995: 124).

2.3.1.4 General equilibrium and the Mundell-Fleming Models

General equilibrium models describe the adjustment process that takes place when the goods, asset and money markets respond to a shock and how all these markets reach a 'general' equilibrium.

The general equilibrium models for exchange rate determination were developed by Stockman (1980) in the 1980s. The determinants of the exchange rate in this model are the demand for domestic goods relative to foreign goods, the difference in the two countries interest rate returns, the demand and supply of money, the demand and supply in the forex market and expectations (Taylor, 1995: 25). For example, if there is a change in preference, which favours domestic goods, the excess demand for domestic goods will have an upward pressure on the domestic currency with the result that the domestic currency appreciates. Nonetheless, the demand side is not the only determinant of the exchange rate; an increase in domestic productivity (holding all else constant) relative to the foreign output may lead to currency depreciation if the demand for domestic goods is lower than the supply (Taylor, 1995: 26).

The Mundell-Fleming model consists of the domestic goods, money and forex markets and four main goods, domestic and foreign currency, and domestic and foreign bonds (Pentecost: 1993: 96). In this model, the money demand and supply, the flow of goods and capital, as well as market expectations affect the exchange rate. Another important factor in the exchange rate determination is whether the source of the shock is local or foreign.

Pentecost (1993: 92-98) explains the dynamics in the context of perfect foresight. The perfect foresight expectation refers to the phenomenon where agents are already aware of changes that might occur in the market; hence, they would most likely not respond to the change and their position towards the domestic currency would remain the same (Pentecost, 1993: 102). For a change to have an impact on the exchange rate in this case, it should be unexpected. Suppose there is an unexpected fiscal expansion, an expansion in which domestic demand and output both increasing. This expansion results in a higher demand for the domestic currency and consequently the domestic currency appreciates (Pentecost, 1993: 105).

According to Pentecost (1993:125), the only limitation of the general equilibrium models of exchange determination is that they assume perfect substitution between the domestic and foreign assets which is far from reality given capital restrictions, risk premiums and so forth, all of which undermine perfect substitution.

2.3.1.5 The Asset-Market Determination of Exchange Rates, the Currency Substitution and the Liquidity Models

The asset market determination of exchange rate models was introduced by Branson in 1976 (Branson & Halttunen, 1979: 55). As described by Branson and Halttunen (1976: 55), the

asset market determination of exchange rate takes into account the factors that determine the exchange rate in the short run. These factors are both domestic and foreign assets: money, stocks and bonds. In equilibrium, for each exchange rate there is a corresponding interest rate at which the demand for money equals the supply of money in the domestic and foreign country. Moreover, the demand for domestic assets equals the supply and the demand for foreign assets equals the supply. Considering an increase in the net foreign assets held by domestic residents, more residents would be demanding the foreign currency which will lead to the depreciation of the domestic currency (Branson & Halttunen, 1979:60).

The currency substitution model was initiated by Calvo and Rodriguez in the late 1970s (Calvo & Rodriguez, 1977: 617-619). The model of currency substitution considers a small country which holds both the domestic and foreign currencies, where prices are flexible and agents are expected to be rational with complete foresight. The domestic residents are assumed to hold a proportion of a particular currency, depending on the returns on of the currency. Therefore the main assumption of this model is that the ratio of the domestic currency held to the proportion of the foreign currency is determined by the expected/actual change in the exchange rate. To illustrate: assume there is a monetary expansion; the domestic prices will increase and the nominal exchange rate will immediately depreciate, resulting in the nominal exchange rate depreciating by a greater magnitude than the rise in the prices. In this instance, the domestic residents will prefer to hold more of the foreign currency (Calvo & Rodriguez, 1977: 621-622).

The liquidity model, which is similar to the asset-market model, was also developed in the 1990s by Lucas (Taylor, 1995: 25-26). In the liquidity model agents are not only required to hold money to buy goods, but also to purchase domestic and/or foreign assets. In this model the exchange rate is mainly determined by the demand for domestic goods as well as foreign goods and bonds. In terms of the dynamics, assume an increase in money supply as a result of a capital inflow; the situation would lead to a decline in the domestic nominal interest rate. However, an appreciation of the domestic currency induces an increase in the demand for the currency for the purpose of purchasing domestic assets (Taylor, 1995: 26).

As much as the asset market and the liquidity models attempt to explain exchange rate determination in a general equilibrium setting, they fail to describe the effect of the flow of goods in determining the exchange rate (Calvo & Rodriguez, 1977). Hence a discussion of

the current account model follows, as it provides a more comprehensive overview of how the goods market affects the exchange rate.

2.3.1.6 The Current Account (Balance of Payment) Model

The current account model (sometimes called the balance of payment model) uses the elasticities and absorption approaches in explaining the relationship between exports, imports and the exchange rate (Mussa, 1977: 97). The equilibrium principle of this model is that the balance of payment determines the demand and the supply of various currencies (Mussa, 1977: 97-98). Therefore, an increase in demand for domestic exports causes an increase in the demand for the domestic currency which, in turn, results in a current account surplus and an appreciation of the domestic currency (Mussa, 1976: 97-98; Isard, 1995: 91-92).

According to Isard (1995: 95) the main limitation of the current account model is the weakness of the assumption that income is considered to be static. Domestic and foreign incomes fluctuate overtime, which means that the current account is prone to fluctuation as a result. Hence, assuming that the income of any country is static overlooks the specifics of the relationship between the current account (or balance of payment) and the exchange rate in the long run.

2.3.1.7 The Portfolio Balancing Model

The portfolio balancing model is one of the newest models in terms of exchange rate determination. The unique aspect of this model is that it assumes foreign and domestic bonds to be imperfect substitutes as a result of factors such as exchange rate and political risks (Taylor, 1995: 25; Pentecost, 1993: 151; Gossel & Biekpe, 2012: 106). Rivera-Batiz and Rivera-Batiz (1985: 489) define exchange rate risk, in the portfolio balancing model, as “the risk associated with more uncovered assets held in foreign currency relative to assets held in the domestic currency”. For domestic bonds to be purchased, given a level of exchange rate risk, the domestic interest rate should be higher than the foreign interest rate plus the rate of depreciation of the domestic currency.

According to Frankel (1983: 96-97), the portfolio model has three variables that determine the exchange rate: the private demand for domestic bonds, the private demand for foreign bonds and wealth. The additional key factors affecting these three variables and thus the exchange rate are the domestic and foreign nominal interest rates (Frankel: 1983: 97). For example, as explained by Taylor (1995: 27), if the domestic monetary authorities decide to engage in open market operations and buy domestic bonds, this will create an upward

pressure on the price of the domestic bonds, leading to a decline in the domestic nominal interest rate. Agents in the market will favour foreign assets to compensate for the losses that they are incurring with the declining domestic interest rate. Greater preference for foreign assets, means that that agents will demand more foreign currencies relative to the domestic currency, which leads the domestic currency to depreciate (Taylor, 1995: 27).

The only shortcoming of the portfolio balancing model is that for empirical evidence to substantiate economic theory, the set of data used in the analysis needs to be available and originating from countries (usually developed countries) with fair bilateral trade and minimal risk differentials (Taylor: 1995: 30).

2.3.1.8 The efficient market hypothesis

The Efficient Market Hypothesis (EMH), when used in the context of exchange rate determination, aims to explain how information in the foreign exchange market leads to a certain exchange rate being fixed. Isard (1995: 83) states that based on the EMH, “exchange rate expectations are formed rationally but conditional on the available information and news in the foreign exchange market”.

Rivera-Batiz and Rivera- Batiz (1985: 493) assert that news from the nominal and real side of the economy as well as political news all affect the movement of the exchange rate. According to Rivera-Batiz and Rivera-Batiz (1985: 493), news about a current account surplus, complemented with an increase in domestic wealth compared to the foreign wealth will result in domestic currency appreciation. Likewise an unexpected increase in the money supply, announced by the central bank, usually leads to exchange rate appreciation. On the other hand, an increase in the budget deficit associated with an increase in the supply of government bonds, given imperfect substitutability, results in exchange rate depreciation. Hence, any news emanating from the financial market, being either from the policy side or other types of news drives the exchange rate.

Based on the discussion of theoretical determinants of the exchange rate, one main point can be drawn from all the models; a change in nominal variables (i.e. change in money supply), real variables (i.e. increase in government spending) and news all determine the exchange rate in the foreign exchange market. The next section covers the empirical evidence on exchange rate determinants.

2.4. Empirical Evidence

This section discusses some of the studies on exchange rate determination, for the case of developed countries, developing countries and specifically South Africa.

2.4.1 Developed countries

Francis, Hasan and Hunter (2002: 19) argue that ever since many countries adopted floating exchange rate regimes, currencies have been more volatile compared to the period of fixed exchange rate regimes. The authors investigated the relationship between the major international equity and currency markets. Their results suggested that there is a bilateral relationship between the equity and currency markets, suggesting that an increase in the volatility of a currency leads to volatile prices in the equity market. Likewise, an increase in volatility of equity prices leads to volatility of currencies to be used during the transactions. The main conclusion, however, is that past currency volatility explains current equity market prices (Francis, Hasan & Hunter, 2002: 23).

Giannellis and Papadopoulos (2011) investigated the causes of exchange rate volatility from 1980 to 1998, in the candidates for, and member states of, the European Monetary Union (EMU). They found that the sources of exchange rate volatility came from the monetary and real sides of the economy and financial market developments; however, the sources varied from country to country. The results in this study indicated that those exchange rate movements can emanate from any side of the economy whether the nominal side, the real side or the financial side.

Similarly, Arratibel, Furceri, Martin, and Zdezienicka (2011) studied the effect of exchange rate volatility of the macroeconomic variables in Central and Eastern Europe for the period 1995 to 2008. They found that the exchange rate became more volatile when these countries moved to a floating exchange rate. Furthermore, their results suggest that lower exchange rate volatility is associated with higher economic growth and capital inflows; unfortunately this lower volatility is also associated with large current account deficit and excess credit (Arratibel et al., 2011: 274).

These findings are consistent with the sticky price model of Hooper and Morton (1980: 12), who established that after the current account experiences a shock, the exchange rate will adjust at a level that is expected to move the current account back to equilibrium. Likewise, Rivera-Batiz and Rivera- Batiz (1985: 171-172), on basis of the current account model, also establish that there is a relationship between the exchange rate and exports and imports.

Kurihura (2012) examined the empirical evidence proving the relationship between monetary policy and the exchange rate for the case of the USA and Japan. The author found that monetary policy instruments induce movements in both countries' exchange rates. Hence short and long-term monetary policy instruments do determine the exchange rate; and the exchange rate also influences the choice of instrument that monetary authorities use for policy-making decisions.

2.4.2 Developing and emerging countries

Bahmani (2011) studied the link between money demand (monetary sector) and exchange volatility of 15 developing countries during the period 1980-2009. The author argues that there are two effects that emanate from this relationship: the wealth effect and expectation effect (Bahmani, 2011: 442-443). In terms of the wealth effect, a depreciation of the domestic currency implies an increase in the domestic value of the assets in a foreign currency held by domestic agents. This condition means that an increase in wealth created by a change in the exchange rate leads to an increase in the demand for the domestic currency. On the other hand, the expectation effect of a depreciation of the domestic currency leads to a decrease in the demand for money as agents expect the domestic currency to depreciate in the future. The findings of the author are ambiguous for different countries. For countries such as Burundi and South Africa, a depreciation of the domestic currency results in a higher demand for money given the rise in wealth (wealth effect). On the other hand, in countries such as Zambia, Uganda and Uruguay, a depreciation of the domestic currency decreases the demand for money based on the expectation of future depreciation, which results in a continued depreciation of the exchange rate (expectations effect) (Bahmani, 2011: 50-51). The findings of this study coincide with the portfolio balance model which states that exchange rate movements are induced by the wealth and the demand for bonds in the domestic and foreign country (Taylor, 1995: 25-26)

Coudert, Couharde and Mignong (2011) investigate the link between exchange rate volatility across financial crises for a sample of 21 emerging economies from January 1994 to September 2009. Their results suggest that exchange rate volatility increases with global financial stress and spreads regionally. The increase in volatility and the contagion are caused by the increased market integration and the fact that investors' perceptions are similar for a specific region. When investors perceive emerging economies to have similar levels of risk, any financial market development leads to a similar response to assets from a specific region,

which then leads to the currencies of neighbouring countries to be volatile (Coudert, Couharde & Mignong, 2011: 3018).

Ogun (2012) studied the factors determining the exchange rate movements in developing countries. The author stress that the exchange rate in developing countries is driven by non-traditional factors in the short term such as corruption, the weather and risk premiums offered in the forex market in order to hold certain currencies. Ogun (2012: 522) argued that these factors are often not captured; hence some of the results for the studies of developing countries may not be completely accurate.

2.4.3 South Africa

Aron and Elbadawi (1999) investigated the consequence of the rand crisis in 1996 and the policy change in favour of a floating exchange rate. They reached the conclusion that moving to a floating exchange rate, having a sophisticated financial market and increased trade liberalisation led to massive volatility in the macroeconomic variables and the exchange rate (Aron & Elbadawi, 1999: 19). This conclusion is in line with the assumption that the more markets are integrated, given a floating exchange rate system, the more the exchange rate is volatile.

Elkhafif (2002) examined the currency substitution model in the case of South Africa. The results of the study suggest that changes in the repo rate led to rapid changes in the exchange rate, resulting in the agents preferring to hold more of the foreign currencies than the rand. The author further stressed that inflation targeting may lead to greater currency substitution, reducing the potency of monetary policy in terms of exchange rate stabilisation (Elkhafif, 2002: 15).

Bhundia and Gottschalk (2003) investigated the sources of exchange rate fluctuations in South Africa, with the period under investigation starting in the first quarter of 1985 up to the second quarter of 2005. Their main focus was to understand the large rand depreciation against the dollar in 2001. The authors found that monetary shocks did cause exchange rate volatility but only in the short run. They further suggest that the main sources of exchange rate volatility are financial developments and the speculative contagion from Argentina, which intensified risk aversion towards emerging countries assets (Bhundia & Gottschalk, 2003: 12).

Similarly to Aron and Elbadawi (1999), they also concur that increased integration intensifies the risk of contagion and also confirms the impact financial developments have on the exchange rate (Aron & Elbadawi, 1999: 19). The findings of Bhundia and Gottschalk (2003) are also consistent with the sticky price model, which Sichei, Gebreselasie and Akanbi (2005:4) also used, establishing that the rand/dollar movements emanate from the nominal and real sides of the economy as well as the financial markets.

Sichei *et al.* (2005) sought to develop an econometric model for the rand-dollar exchange rates for the period of 1994 to 2004. Their findings led them to offer four suggestions. Firstly, in the event of an increase in the money supply, agents revise their exchange rate expectation downwards which leads to capital flight and thus depreciates the exchange rate proportionately to the increase in the money supply. Secondly, when the monetary policy committee announces an increase in the domestic interest rate, which increases the interest differential, the exchange rate depreciates for the first eight quarters and then the intended appreciation takes place. Thirdly, an increase in GDP is said to cause an exchange rate appreciation over thirty quarters. Fourthly, an increase in inflation leads to exchange rate depreciation over five quarters, whilst an exchange rate shock leads to the rand depreciation over 30 quarters until the exchange rate appreciates again (Sichei, Gebreselasie & Akanbi, 2005: 15-17). These results suggest that sources of exchange rate volatility are partly internal given a change in monetary policy (money supply and/or interest rate), investors' expectations, shocks from the exchange rate and the real side of the economy. Once again the rand/dollar exchange rate confirms the dynamics proposed in the sticky price model, namely that following a change in the money supply, the exchange rate temporarily depreciates below its long-term equilibrium level to then appreciate until it reaches its previous equilibrium level (Gardeazabal & Regulez, 1992: 8-15; Pentecost, 1993: 134).

Fedderke and Flamand (2005) investigated the effect of news on the rand/dollar exchange rate from June 2001 to June 2004. The authors found an asymmetry in the way news is locally absorbed. They stress that news does have an impact on the rand/dollar exchange rate but only the good macroeconomic news (e.g. increase in economic growth in the USA) affects the exchange rate rather than bad news. In addition, Fedderke and Flamand (2005) argue that news from the real and nominal side of the economy affects the rand/dollar exchange rate. However agents pay more attention to the information originating from the USA than from South Africa (Fedderke & Flamand, 2005: 13).

De Bruyn, Gupta and Stander (2015: 30) investigated the validity of the long-term monetary model in exchange rate determination for the case of South Africa. Their results suggest that indeed in the long run money supply, output and the exchange are cointegrated. However the short-term results had very little explanatory validity, because the monetary models restrictions were not justified by the empirical results (De Bruyn, Gupta & Stander, 2015: 30).

2.5. Conclusion

This chapter provided an overview of the theoretical and empirical literature discussing the determinants of the exchange rate and the sources of its volatility. The historical background indicated that switching to a floating exchange rate system increased the exchange rate volatility as a result of increased market integration and the fortified power of financial developments on agents' expectations. Based on the various theoretical models on exchange rate determination, one main point comes across suggesting that the exchange rate is determined by monetary shocks (e.g. money supply), real shocks (e.g. GDP) as well as financial developments which are created through a change in agents' expectations and their risk aversion. The theories on exchange rate volatility also highlight that the three fundamental determinants of exchange rates are also the sources of exchange rate volatility. However the extent of market integration and ongoing financial developments are the main sources of exchange rate volatility. The gap in the theoretical literature is based on two points: one, most theories of exchange rate determination use the partial equilibrium approach to exchange rate determination; two, the general equilibrium approach, such as the Mundell-Fleming, do not include news as an exchange rate determinant.

The empirical findings validate the theories discussed. The gap in the empirical literature is that most researchers mostly use the sticky price model to exchange rate determination relative to other models. The aim of the study fills the gap in the theoretical and empirical literature by using a comprehensive approach to exchange rate determination, using nominal, real, and financial and news variables to exchange rate determination. Although sources of exchange rate volatility vary from country to country, South Africa was shown to be mostly affected by monetary policy, financial developments and news.



Chapter Three

3. Methodology

3.1. Introduction

This chapter reviews the econometric methods used to analyse the determinants of the rand/dollar exchange rate. A discussion of these methods helps to clarify the important components and stages of the analysis. The chapter is divided into four sections. Firstly, section 3.2 covers the data and sources of the variables used in the study. Secondly, section 3.3 deals with the specification of the model; more precisely, a review of the literature on the model used to analyse the exchange rate dynamics in the short run. Section 3.4 discusses the method used to analyse the long-run dynamics of the relationship between the rand/dollar and its determinants. Section 3.5 will provide a brief account of the robust checks done on the models. This is followed by a concluding Section 3.6 summarising the chapter.

3.2. Data

3.2.1. Data sources

This study uses monthly data from January 1995 to December 2014. Although the United States Volatility Index (VIX) and the rand/dollar exchange rate are available at a daily frequency, all the data have been harmonised to a monthly frequency. Furthermore, using monthly frequency data makes it possible to gather a sample large enough to yield more accurate results.

The data we have is available in two sets: one for the USA and the other for South Africa. The USA has been chosen among other various options (such as the Euro zone) to represent the external source of exchange rate movements. The reason why the USA is a preferable option, for a foreign country in terms of currency studies, is the fact that the US dollar is a global ‘vehicle currency’, because it is the most used currency, globally, in bilateral trades by non-dollar countries’ agents (Devereux & Shi, 2001: 1). South Africa is the domestic country from which the internal sources of exchange rate movements emanate².

For the US industrial production index and Consumer Price index (CPI) for the USA were gathered from the International Monetary Fund data base, International Financial Statistics. In addition, the Federal funds rate along with the total share index, 10-year bond yield (T-

² Internal sources of exchange rate movements are domestic shocks that emanate from a change in monetary policy, the real sector or financial markets.

bill) and VIX, all for the US, were gathered from the Federal Reserve Bank of St. Louis database, FRED. For South Africa the prime rate, the industrial production index, the 10-year bond rate and the rand per US dollar exchange rate were sourced from the South African Reserve Bank. Lastly, the CPI and total share indices for South Africa were also sourced from FRED. In this study, the data manipulation is performed with the aid of E-Views 9.

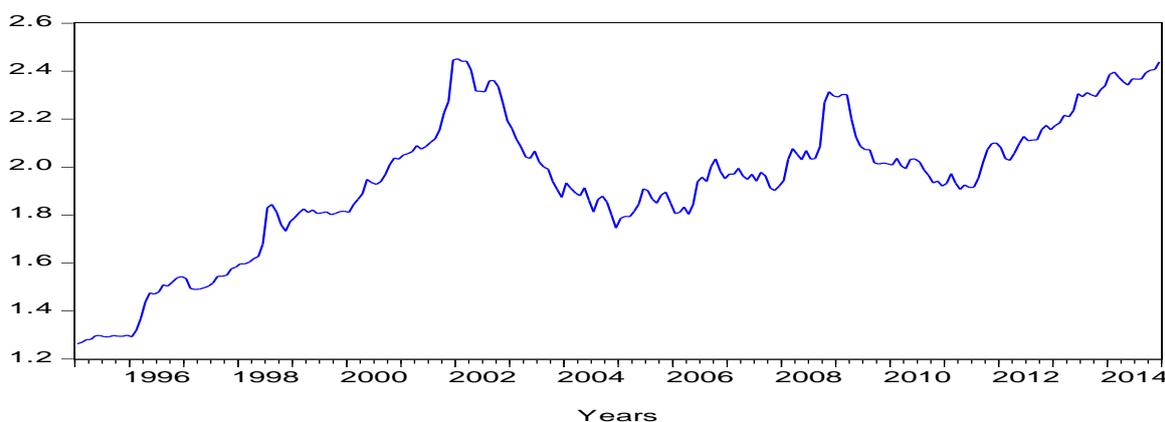
3.2.2. Variables

The dependent variable in the model is the rand per US dollar exchange rate presented in rand/dollar. The baseline model serves to assess the relationship between the domestic/internal fundamental determinants and the rand per US dollar exchange rate (EXC). The regressors are monetary policy with the prime rate (m) and the Fed rate (m') as proxies; output used as a proxy for the business cycles is represented by the South African industrial production index (y) and the US industrial production index (y'). The asset market interest rate which is represented by the South African 10-year T-bill rate (i) and the US 10-year T-bill rate (i'), and inflation which is represented by the South African CPI (π) and the US CPI (π').

The extended model depicts the relationship between the rand/dollar exchange rate and the financial market variable represented by the South African total share index (TOTSZA). The Volatility Index (VIXUS) is used in the USA and acts as proxy for news in the model. All the variables are expressed in logarithmic form, except the interest rates.

3.2.2.1 The Rand/Dollar Exchange rate

Figure 3.1 The Rand per US Dollar Exchange Rate (January 1995-December 2014)



As presented in Figure 3.1, from 1995 to 2001 and from 2010 to 2014, the exchange rate has been showing an upward trend. The rand started depreciating in 1996 as a result of the uncertainty around the alleviation of the exchange rate restrictions (South African Reserve

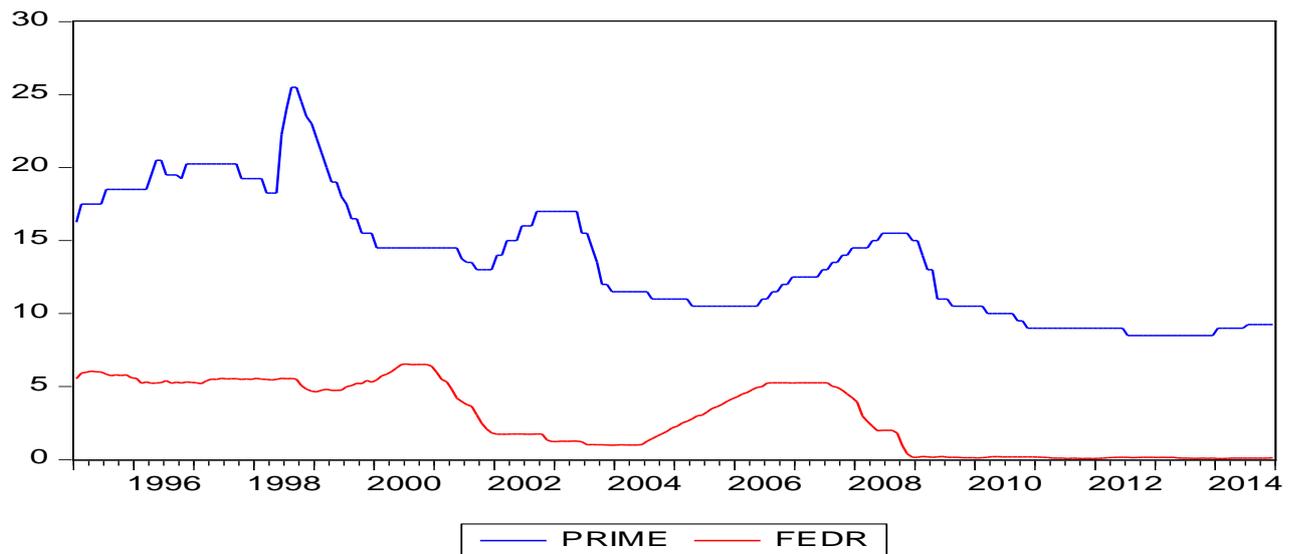
Bank, 1998: 62). The rand depreciated further as a result of the spill-over effect of the Asian crisis in 1997, which heightened aversion towards emerging economies' currencies and assets (South African Reserve Bank, 1998: 62).

In 2001, the rand/dollar exchange rate showed a downward trend and experienced high levels of volatility which ended in early 2007. Bhundia and Gottschalk (2003: 10) identified a few reasons for the large and sudden depreciation in the rand/dollar, in 2001. The South African Reserve Bank adopted an expansionary monetary policy stance in 2001, which led to the depreciation of the rand against other currencies. During that year, the growth of the money supply accelerated and interest rates were also lowered. In terms of external source of volatility, the rand suffered from speculation as a result of contagion from events in Argentina and Zimbabwe which were experiencing currency crises. Consequently, there was a rise in investors' aversion towards emerging economies assets and currencies. Lastly, the USA was experiencing a minor recession during that time. This meant that the volume of imports from South Africa fell, leading to the depreciation of the rand/dollar (Bhundia & Gottschalk, 2003: 10-12).

In 2008, the rand depreciated by 0.4% points as a result of the contagion emanating from the 2007-2009 financial crisis. During the 2007 financial crisis the reduction in financial activity, liquidity problems and heightened risk aversion towards emerging economies' assets led to a decrease in the demand for the rand and rand-denominated assets, which all led to the large depreciation in the currency (South African Reserve Bank, 2008a:28).

3.2.2.2 The Prime Rate and the Federal Reserve Funds Rate

Figure 3.2 South African Prime Rate and Federal Reserve Rate (January 1995-December 2014)



The prime rate which is used as a proxy for monetary policy and the Federal Reserve rate are illustrated in Figure 3.2. Both rates have been following a downward trend, although the prime rate remains higher than the Federal Reserve rate.

In August 1998, the prime rate reached a peak of 25% because of the rise in the repurchase rate of the Reserve Bank and the reduction in the bank's operating margins (South African Reserve Bank, 1998: 67). The prime rate declined afterwards until it rose again in 2002 as a response to the sharp depreciation of the rand in 2001 and the rise in the repurchase rate, the prime rate increased in 2002. (South Africa Reserve Bank, 2003: 57). The last peak of the rate occurred in 2008, when the prime rate rose as a response to the rise in the repurchase rate in April and June 2008 (South African Reserve Bank, 2008b: 38). Since then, the prime rate has stabilised around 8%.

The Federal Reserve rate reached two peaks during the period of the study. The first high occurred in the last two quarters of 2000 and the second in the first quarter of 2006 and lasted until the last quarter of 2007. The Federal Reserve Bank decided to increase the Federal Reserve rate in 2000 following a threat of rising inflation, slowly expanding labour market and market expectations of a tightening of monetary policy (Federal Reserve Bank, 2000: 3-4). The Federal Reserve rate was increased again in 2006, due to the rise in oil, energy and food prices, which were threatening to aggravate the pre-existing inflationary pressures (Federal Reserve Bank, 2006: 4-5). After 2007, the Federal Reserve Bank decided to cut the rate close to zero bound in order to counter the slow growth (Federal Reserve Bank, 2007: 5).

3.2.2.3 Industrial Production Index

The industrial production index is used as proxy for the economic activity and the business cycle for both countries.

Figure 3.3 Industrial Production Index South Africa and United States (January 1995-December 2014)

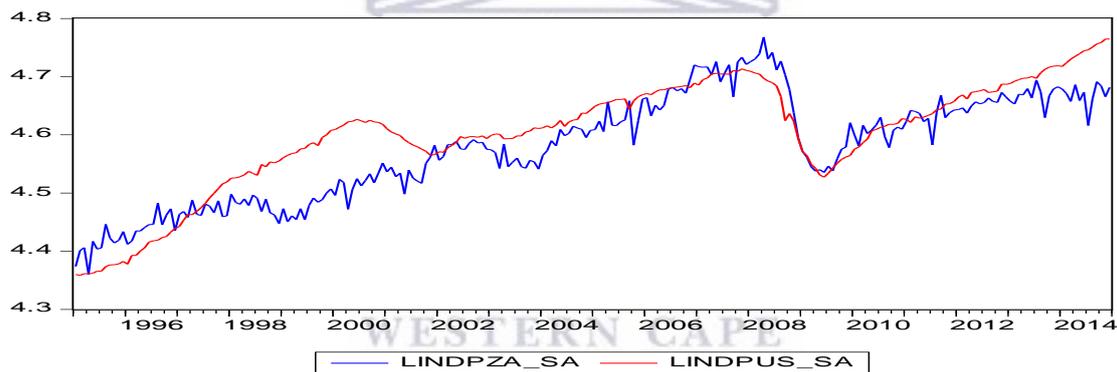


Figure 3.3 shows the South African and United States industrial production indices. Both indices have been showing an upward trend.

Economic growth in South Africa was slow in 1996. More precisely, manufacturing sector output, at that time fell by 6% relative to the previous year. The reasons for this deceleration were the reduction in households' expenditure and cuts in inventory accumulation (South Africa Reserve Bank, 1997: 14). In the fourth quarter of 2007, the industrial production index reached a peak of 4.7 but fell drastically in the next quarter (South Africa Reserve Bank, 2008a: 6). According to the South African Reserve Bank (2008a:6), the decline in the index was the consequence of a number of factors such as load shedding, weaker global demand, high input costs and slower domestic real income. Like most economic indicators, the industrial production index dropped significantly from 2008 to 2009, as a result of the

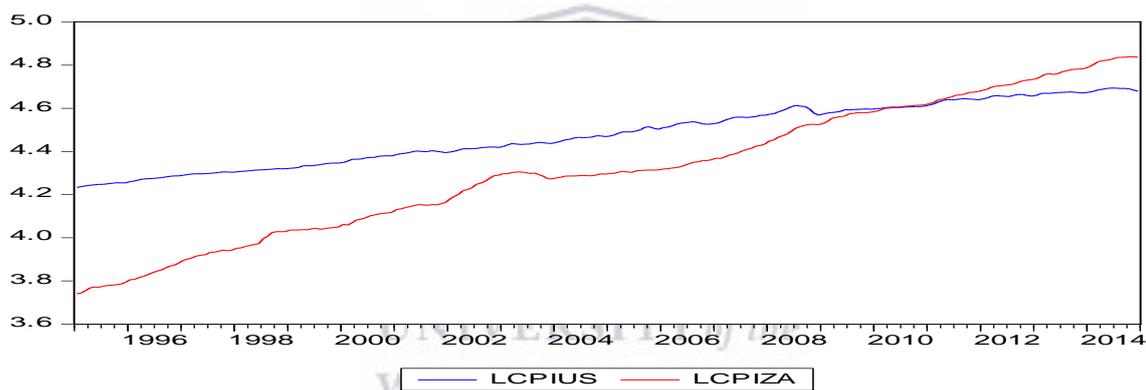
contagion sprung by the global financial crisis. The index started to rise again, following a steady upward trend.

The industrial production index showed an upward trend from 1995 to 2014, except on two occasions when it decelerated in 2001 and 2008. The deceleration that occurred in 2001 was the result of a weakening demand, cuts in inventories and machinery, and a reduction in the demand for US products (Federal Reserve Bank, 2001: 3). In 2008, most sectors of the US economy, including the manufacturing sector experienced great losses and declines in activity after the housing market bubble burst (Federal Reserve Bank, 2008: 3).

3.2.2.4 Inflation

CPI serves as a proxy for inflation or price levels. Both indices are calculated using 2010 as a base year.

Figure 3.4 Consumer Price Index South Africa and United States (January 1995-December 2014)



The Consumer Prices (CPI) Indices for both countries are shown in Figure 3.4. Unlike the South African CPI, the US CPI has been showing quite a steady growth.

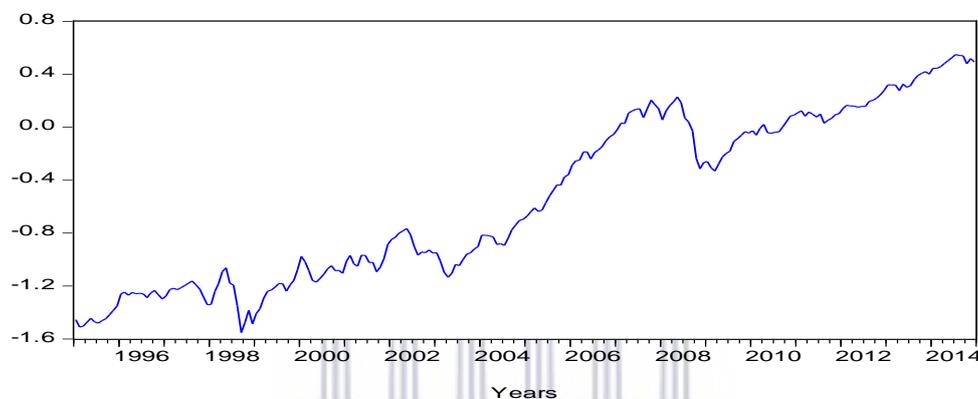
The US inflation rate has been following a steady pattern. The steadily progressive growth in CPI was interrupted by a sudden rise in inflation in 2007. This rise in consumer prices was fuelled by the rise in the prices of oil, commodities, energy and food (Federal Reserve Bank, 2007:3).

In South Africa, the CPI reached two peaks during the period considered in the study. CPI reached a peak of 4 index points in 1998. The reason for this high rise in CPI was the depreciation of the rand and the rise in long term yields (South African Reserve Bank, 1999: 15). A combination of elements led to the rise in CPI in 2002. The elements responsible for the acceleration in prices are the sharp depreciation of the rand in 2001, the increase in

international oil and food prices, and the drought experienced in the Southern African region (South Africa Reserve Bank, 2003: 27). Thereafter the CPI continued to accelerate until it reached a peak of 4.8, because of higher international food prices, and rising electricity and labour costs which contributed to the rise in agricultural producer-increased prices (South Africa Reserve Bank, 2015: 31).

3.2.2.5 Total Share Index

Figure 3.5: Total Share Index- South Africa (January1995-December2014)



Similar to most financial variables, the total share index of South Africa does not follow a regular pattern, as seen in Figure 3.5. The total share index was at a low of -1.6 in 1998 due to local and international factors. The Asian crisis affected investors' perception of emerging economies' shares, not only South Africa; however this international effect on shares was aggravated by the nervousness of local presidential pre-elections (South Africa Reserve Bank, 1999: 36). In 2003, the total share index fell despite the upward growth it had been experiencing since 1999. The reason for this mild deceleration was the weakened rand, which reduced the profitability of rand denominated assets (South Africa Reserve Bank, 2003: 74). The index experienced another fall in 2006 as a result of investors' response to the negative sentiment toward emerging financial markets, the increased repo rate and the lower commodity prices (South Africa Reserve Bank, 2007: 67).

3.2.2.6 Ten Year Bond rate

Figure 3. 6: Ten-Year Bond rate South Africa and United States (January 1995-December 2014)

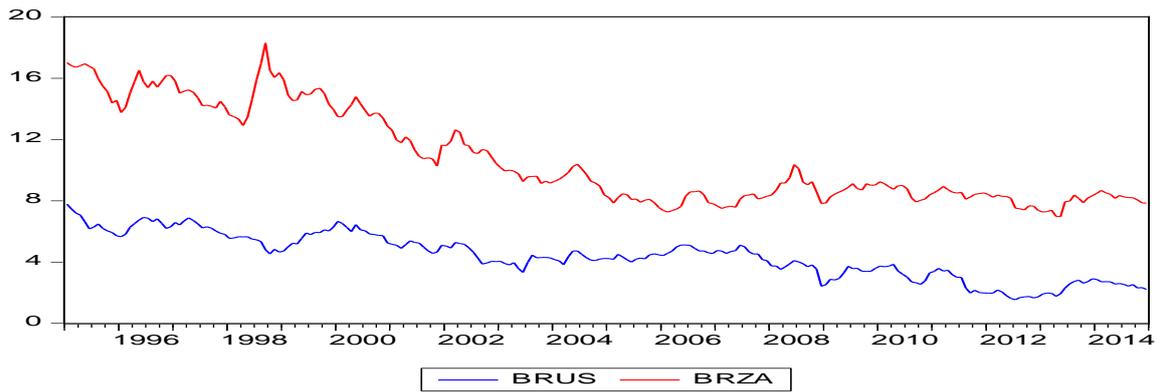


Figure 3.6 shows the 10-years bond yields for South Africa and the United States. Similarly to the total share index, bond yields do not follow a particular pattern.

The United States 10-years yield showed a steadily downward trend. It hovered around 4% from 2008 until 2014. The yield fell sharply in 2012 as a result of the reduced demand for long term assets following the European crisis (Federal Reserve Bank, 2012: 16-17).

The South African 10-years bond rate decelerated from 1999 until 2004, when it stabilised around the 8% to 12% range. In 2013, the 10-years bond yield reached a trough of 8% as a result of the growing risk aversion of non-residents towards emerging markets and the origination of the first South Africa corporate bond default (South Africa Reserve Bank, 2014: 63).

Figure 3.7 Volatility Index- United States (January 1995- December 2014)

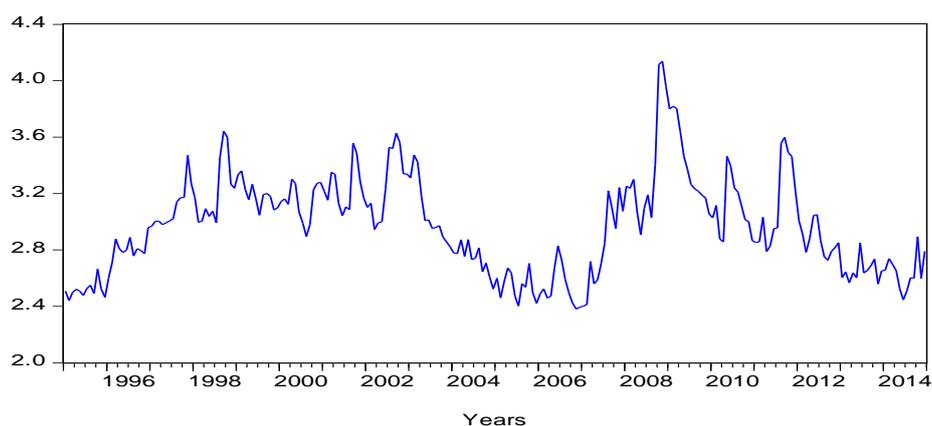


Figure 3.7 depicts the Volatility Index (VIX) of the financial markets in the USA. VIX is defined by Baker, Bloom and Davis (2015: 12) as “an index of 30 days implied volatility of the US S&P 500 stock”. According to the Federal Reserve Bank, starting from 2009 until the end of 2012, the US financial market experienced a lot of volatility. The fluctuation was the

result of the turmoil caused by the bursting of the housing bubble, which spilled over to all sectors of the economy and mostly affected the banking and financial markets, raising the level of uncertainty in the market (Federal Reserve Bank, 2008: 11-12). The events of volatility in the financial market occurred again in 2011-2012 following the European fiscal and debt crisis, which led to heightened investors' risk aversion towards stocks and bonds (Federal Reserve Bank, 2011: 26).

3.3. Model specification

3.3.1. Model identification and restrictions

Model identification deals with the selection and ordering of the variables, whilst the model restriction deals with the assumptions used or limitations imposed on the model for it to make econometric sense (Pierse, 1999: 5). Gottschalk (2001:24) breaks down how this process is undertaken in the structural VAR methodology. The author explains that the SVAR model firstly takes all the variables as endogenous (part of the model), which then leads to simultaneous equations being created as each variable is taken as a function of all the other variables. Thereafter elements of these equations are separated into expected and unexpected values. Lastly the restrictions, often based on strong theoretical foundations, are imposed on the unexpected values (Gottschalk, 2001: 24).

The identification and restrictions of this study will be based on a monetary model of exchange rate determination, more specifically the sticky price model developed by Dornbusch (1977), Frenkel (1979), and Hooper and Morton (1982). The sticky price approach to exchange rate determination is deemed most appropriate for a number of reasons.

First, the model's basic assumptions are more empirically valid; since the exchange rate is allowed to overshoot in the short run, prices can adjust slowly as markets clear after a shock and changes in interest rates lead to changes in the exchange rate. Second, the premises of the sticky price models are more realistic relative to those of the general equilibrium models. Some of the assumptions of general equilibrium models are that currencies and bonds are perfect substitutes and agents have perfect foresight (Pentecost, 1993: 105; Taylor, 1995: 25-26). These assumptions have been proven to be false because agents do not always have perfect foresight and the differing values of risk premiums make currencies and bonds imperfect substitutes. Third, the determinants of the exchange rate and the magnitude of their effect on its behaviour change with monetary regimes (Mtonga, 2011: 34). Given the change in the monetary policy regime in 2000, the sticky price model is the only theory which

substantiates the relationship between the policy instruments and the exchange rate. Fourth, the sticky price model includes a broader range of determinants relative to partial models: these include the asset market, currency substitution, current account and portfolio balancing models. Lastly, we use the sticky model because it has been used and tested by Bhundia and Gottschalk (2003), Faust and Rogers (2003), Sichei, Gebreselasie and Akanbi (2005), Mtonga (2011) and De Bruyn, Gupta and Stander (2015) in the context of exchange rate dynamics in South Africa.

We follow the methodology of Bhundia and Gottschalk (2003), Sichei, Gebreselasie and Akanbi (2005), and De Bruyn, Gupta and Stander (2015). However the model used in this study will have an extension, as we introduce financial market variables and news as important determinants of the exchange rate. In the light of the extension, we will be informed by the methodology used by Gossel and Biekpe (2012: 108) who introduced financial variables in their VAR model as determinants of the rand/dollar exchange rate. The authors stressed that the rand switched to a financial currency in 1995 as the floating exchange rate was adopted, so it is crucial to include financial market variables for any period after 1995 (Gossel & Biekpe, 2012:12). The additional variables are the total share prices, and the volatility index which are all proxies for financial developments and news.

The price of a currency carries some of the information related to economic policy which also coincides with the EMH theory as previously discussed in chapter two. As suggested by Fedderke and Flamand (2005: 13) news from the US affects the rand/dollar exchange rate more than news from South Africa. VIX index will serve as a proxy for news indices which affects the rand/dollar.

Based on the sticky price model as created by Hooper and Morton (1980: 6-9), presented by Gardeazabal and Regúlez (1992: 9-14), Pentecost (1993), Isard (1995: 118-119) and Taylor (1995: 23-25), and empirically used by Bhundia and Gottschalk (2003), Fedderke and Flamand (2005) as well as De Bruyn, Gupta and Stander (2015), our model will have four restrictions. Firstly, money supply and money demand are assumed to be equal and the money market in each country is in equilibrium. Secondly, the purchasing power parity condition is assumed to hold in the goods market. Thirdly the uncovered interest rate parity condition is assumed to hold, therefore bonds are imperfect substitutes. Lastly, an expected change in the domestic exchange rate is expected to equal the interest differential, so as to compensate investors for a future depreciation of the currency (Pentecost, 1993: 63).

In terms of short term dynamics, the price and the exchange rate clear the goods market and the money market (Gardeazabal & Regúlez, 1992: 9-14). Assuming an increase in the money supply, the exchange rate would depreciate, which leads to an increase in the demand for exports. The increase in the demand for exports will require prices in the goods market to also rise to maintain the market in equilibrium. On the other hand the increase in the price, because of the increase in the money supply, lowers the demand for money which then leads to an increase in the interest rate for the money market to clear. Therefore in the short run, an increase in money supply induces an even greater change in the exchange rate (Pentecost, 1993: 106-109; Taylor, 1993: 24).

The short-run model of the rand/dollar is given by equation1:

$$(1) exc = (m_t - m'_t) - \alpha(y_t - y'_t) + \gamma(\pi_t - \pi'_t) - \beta(i_t - i'_t) + \varepsilon_t.$$

The term “exc” represents the rand/dollar exchange rate, m_t the domestic money supply, m'_t the foreign money supply, y_t the domestic output which has industrial production as its proxy, y'_t the foreign output, π represents the price levels in South Africa, π' is the price levels in the US, i_t is the yield of a 10-year T-bill of South Africa, i'_t is the yield of a 10-year T-bill of the USA and ε_t is the error term. All the foreign variables and money supply variables are all taken as exogenous variables, this is as the money supply is fixed by the Central Bank and foreign variables are determined outside the borders of the domestic country (Isard, 1995:121).

The extended model is based on the Efficient Market Hypothesis which states that exchange rate expectations are formed rationally but conditional on the available information and news in the foreign exchange market (Isard, 1995: 83). The extended model is presented in equation2:

$$(2) exc = C + \beta_1(m_t - m^*_t) - \beta_2(y_t - y^*_t) + \beta_3(\pi - \pi^*) - \beta_4(i_t - i^*_t) + \beta_5(tsZA_t) + \beta_6(VIX) + \varepsilon_t.$$

In the extended model, the exchange rate is determined by the nominal variables (money supply), the real variables (output) and financial developments represented by the total share indices of both countries, and the volatility index for the USA. As discussed in the findings of Gossel and Biekpe (2012: 112) stock returns do explain movements in the rand/dollar exchange rate. Based on their findings we will measure how much the all share indices of South Africa ($tsZA_t$) affects the rand/dollar. Furthermore, as Bhundia and Gottschalk (2003:

12) pointed out in their findings, one of the main determinants of the rand/dollar exchange rate fluctuations is financial development. Fedderke and Flamand (2005: 13) further clarified that it is mostly news from the United States that affects the rand/dollar exchange rate; it is based on those premises that we will add VIX in the extended model.

Once short term exchange rate dynamics are analysed, the next step will consist of examining long term links between the rand/dollar exchange rate and its determinants.

3.3.2. Vector Autoregression Models

Vector Autoregression (VAR) models were created by Christopher Sims in 1980 (Stock & Watson, 2001: 1). Brooks (2008: 290) defines a VAR model as “a systems regression model that has more than one dependent variable and can be considered as a hybrid between a univariate model and simultaneous equation time series model”. Bjørnland (2000:3), in agreement with Stock and Watson (2001), states that VARs are powerful and coherent tools to build structural inferences, policy analysis and forecasting. Lütkepohl (2011:2) also recognised that the purpose of VAR models is to describe and portray the dynamics of variables.

Equations 3 and 4 show a typical VAR model:

$$(3) Y_{1t} = \beta_{10} + \beta_{11} Y_{1t-1} + \dots + \beta_{1k} Y_{1t-k} + \alpha_{11} Y_{2t-1} + \dots + \alpha_{1k} Y_{2t-k} + u_{1t}$$

$$(4) Y_{2t} = \beta_{20} + \beta_{21} Y_{2t-1} + \dots + \beta_{2k} Y_{2t-k} + \alpha_{21} Y_{1t-1} + \dots + \alpha_{2k} Y_{1t-k} + u_{2t}$$

The model above is a typical bivariate VAR model, which contains two equations with two variables Y_{1t} and Y_{2t} whose current values are determined by the current and past values of the two variables, as well as the error terms (Brooks, 2008: 290). The core conditions of the model are that the error terms follow a white noise process $E(u_{it}) = 0$ and are not correlated $(u_{1t}, u_{2t}) = 0$. Alternatively, the model can also be expressed in a more concise form such as illustrated in equation 5:

$$(5) Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_k Y_{t-k} + u_t$$

One of the main properties of the VAR models is that they are flexible; a VAR model can contain multiple variables for which there are multiple equations (Brooks, 2008: 290). Additionally, current values of a variable are partly explained by the past variable of the specific variable (Lütkepohl, 2011: 2). Nonetheless this correlation does not mean that the error terms of each regression are correlated. Instead there is a feedback process created

between VAR model variables (Enders, 2014: 285). While the error term can be contemporaneously correlated with the equations of the other variables; the error term has to be uncorrelated with its lagged value. Since error terms are uncorrelated with their own lagged values, the error terms for each regression equation are simply shocks that follow a white noise process and each has a mean of zero and a constant variance (Enders, 2014: 285-286).

Some of the advantages of VAR models are that they are easy to interpret, they provide an orderly way to impose restrictions and they capture empirical consistencies other models do not provide (Bjørnland, 2000: 5). Additionally, in terms of model restrictions, the structural VAR is very flexible in the sense that the model restrictions can be frequently modified until they better reflect the theory, while they allow the structural shocks to be complete innovations and completely uncorrelated (Gottschalk, 2001: 17). Furthermore Brooks (2008:291) also describes a few advantages of the VAR model: one, all the variables are treated as endogenous, so there is no need for identification restrictions; two, the current values of variables can depend on their lags and combinations of white noise error terms, which enables one to capture more information from the data.

Giannini and Mosconi (1987: 301), echoed by Bjørnland (2000), state that one of the drawbacks of the VAR models is the fact that an increase in the numbers of variables included in the model may lead to an increase in the error term. These limitations mean that the reader and the researcher should not rely completely on the evidence provided by the VAR model. Another criticism of VAR models is that they use little theoretical information about the relationships between the variables, leaving no clear direction as to how the model should be specified (Brooks: 2008: 291). This issue leads the researcher to pay attention to the ordering of variables in order to avoid misleading results (Faust & Rogers, 2003: 1406, Lütkepohl, 2005: 66).

The ordering of variables is often based on macroeconomic assumptions and theories; however, these are not always sound (Lütkepohl: 2005: 66). Christiano, Eichenbaum and Vigfusson (2005:4) also argue that VAR models may not explain the dynamic responses of macroeconomic variables to shocks in a long-run setting.

There are three types of VARs, according to Stock and Watson (2001). The first type is the reduced form VAR which is described as a linear function of a variable and its past values,

past values of all other predetermined variables controlled for, and a serially uncorrelated error term” (Stock & Watson, 2001: 3).

The second type is the recursive VAR which first constructs the error terms of each equation and ensures that they are uncorrelated with the preceding equations. In the case of recursive VAR, as argued by Stock and Watson (2001: 3), the order of variables in the regression equation highly influences the results of the regression.

The last type is the structural VAR which uses economic theory to explore and explain relationships between variables (Gottschalk: 2001 13). Structural VARs serve to identify and sometime confirm pre-existing relational assumptions about economic variables (Stock & Watson, 2001: 4). Based on the arguments advanced by Stock and Watson (2001) and Gottschalk (2001) the structural VAR is the most appropriate method to use for our study, since it explores variable dynamics using the appropriate theoretical premises.

According to Kilian (2011: 1), structural VAR models have four main functions. Firstly, they can be used to analyse the response of a set of variables to a one-time structural shock. Secondly, they allow the researcher to construct a forecast error variance decomposition which can quantify by how much a structural shock affects each variable and the model as a whole. Thirdly, SVAR allows measuring the cumulative contribution of each structural shock to the evolution of each variable over time. Fourthly, structural VAR models allow the construction of a forecast scenario based on hypothetical sequences of future structural shocks (Kilian, 2011: 1).

3.4. Cointegration

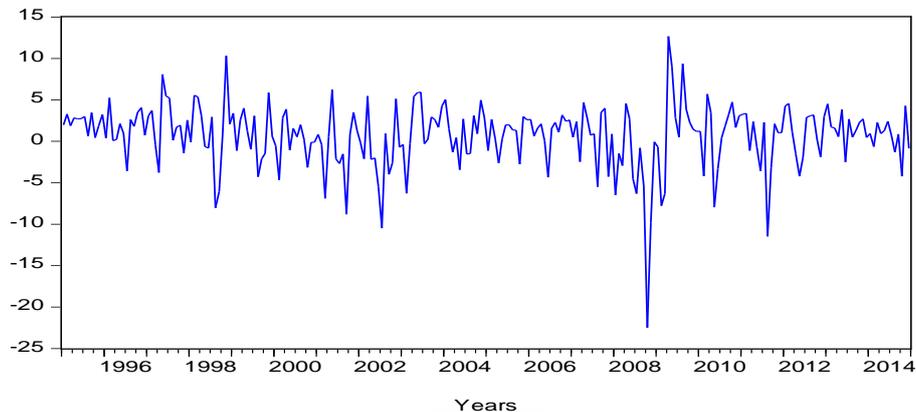
Cointegration refers to the econometric analysis of long-term relationships of time series variables (Lütkepohl & Krätzig, 2004: 88). Once variables are tested and proven to be stationary, the data can be explored to establish whether there are any long-term relationships (Bachmann, 2012:20). Variables are recognised as cointegrated when they behave similarly in the long run.

3.4.1. Stationarity process: unit root test

Lütkepohl and Krätzig (2004: 11) define a stationary process as one where a variable fluctuates around a constant mean over time and is time invariant. Put differently, Brooks (2008: 291) describes a stationary series as one whose mean, variance and autocovariances are constant for each lag, and in the event of a shock it fades away with time. In other words,

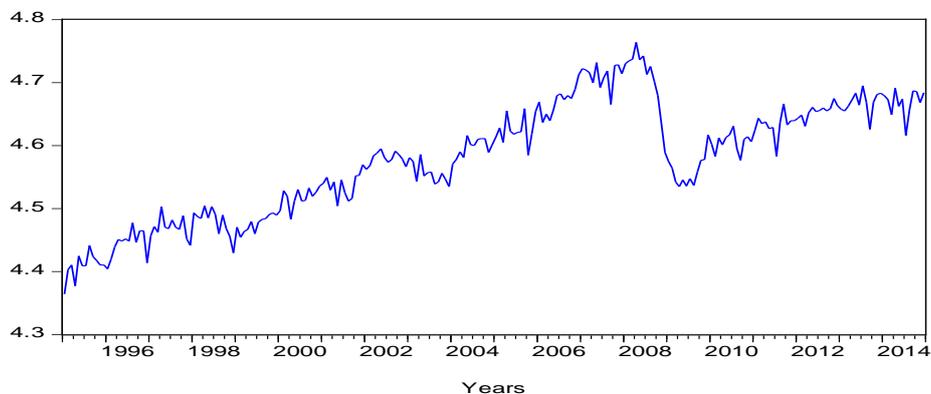
a variable is said to be stationary when it reverts back to a mean over time and does not change its behaviour overtime or in different period. In econometric terms, a stationary variable is said to have no unit root. A good example of such a variable is the US total share index show in Figure3.8 below.

Figure 3.8 Stationary variable



The contrary case of a stationary process is a variable which is non-stationary. A non-stationary variable is one that does not fluctuate around a constant mean; instead it is time variant and behaves differently over time. As Chan (2002: 94) points out a non-stationary variable increases in the mean level over time. Such a variable is said to have a unit root. Additionally, in the event of a shock, the innovation persists infinitely (Brooks, 2008: 318). A good example of non-stationary variable is the US industrial production index illustrated below in Figure3.9. The industrial production index follows a random walk with drift, as the index rises and falls at any point in time, without following a particular pattern.

Figure3.9 Non-stationary variable



For a model to provide accurate results, the variables in the model and the model itself have to be stationary (Bachmann, 2012: 21). The challenge of applying econometric and statistical

analyses on a non-stationary series is that they lead to spurious regressions, as statistically the results may be significant when in actuality they are not, thus leading to misleading results and refutable inferences (Brooks, 2008: 319).

Brooks and Tsolacos (1999:9) argue that all the variables included in a VAR model have to be stationary in order to carry out the different tests. Sometimes in order to render variables stationary, one has to take the first differences of the variables. Therefore variables, used in the study, that will be found to be non-stationary will be first differenced. As Enders (2014: 291) explains the process of taking first differences, he insisted that this is aimed at removing the unit root; however, it results in a loss of information concerning long-term comovements. The implication of taking first differences overlooks short-run deviations from the long term equilibrium; which leads to the loss of information as short-run deviations help to explain long run movements (Enders, 2014: 291).

Several tests have to be done in order to identify the presence of a unit root in a variable or a model. The null hypothesis of the first test suggests that there is a presence of a unit root and therefore the variable or model is non-stationary (Lütkepohl & Krätzig, 2004:53). The presence of a unit root means that there is a presence of autocorrelation among the variables in the model. The presence of autocorrelation means that there is a relationship between the error terms and regressors, which leads to misleading results (Brooks, 2008: 139). The implication of autocorrelation and the presence of a unit root in the system is that shocks captured in the error term persist. If the shock in the system persists the resulting inference is likely to be untrue. Two common tests used are the Augmented Dickey-Fuller and Phillip-Peron Tests. The null hypothesis of these tests suggests that there is a unit root in the variables (Lütkepohl, 2004: 54; Brooks, 2008: 330). The alternative to the tests is that there is no unit root in the variables. The only reservation about the ADF and PP tests is that when the sample size is small, it contains little information and the data may identify as stationary (Brooks, 2008: 331).

A way to counter the presence of a unit root in the series is to first difference the variables (Brooks, 2008: 326). Once the series are first differenced, the unnecessary noise is removed from error terms and a more stationary process is obtained. Although there is no consensus in the literature, opponents of first differencing the series argue that it takes away valuable information, and as a result the true behaviour of the series is not reflected (Brooks, 2008: 293).

3.4.2. Johansen Test

Once the stationary process is achieved, the next step is to investigate whether there are any long-term relationships in the series. The Johansen test is often used to assess whether variables are cointegrated in the long run (Bachmann, 2012: 22). Variables are said to be cointegrated when they behave similarly in the long run and reach a similar long-run equilibrium (Mireku, Sarkodie & Poku, 2013: 33).

According to Enders (2014: 46-47), variables are cointegrated if they satisfy four properties. Firstly, the variables have to be linearly integrated in the long run. Secondly, variables have to have an equilibrium relationship in the long run. Thirdly, there is a feedback mechanism among the variables which influences the ordering of the variables in the model. Lastly, variables and the model have to follow a stationary process after the cointegrating vector has been identified (Enders, 2014: 47).

The two main statistics of the Johansen test are the trace and the maximum eigenvalues tests (Bachmann, 2012: 22). Supposing system presented in section 3.3.2 is rewritten as an error correction form in equation 6:

$$(5) Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \dots + \beta_k Y_{t-k} + u_t$$

$$(6) \Delta Y_t = \Pi Y_{t-k} + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \dots + \Gamma_{k-1} \Delta Y_{t-(k-1)} + u_t$$

In the error correction model, Π is a matrix containing the long-run coefficients, the matrix Γ_1 contains the short-term coefficients and u_t is the error term. The trace test is used to estimate the number of long run relationships (ranks) there are in the matrix Π (Brooks, 2008: 350-351). The null hypothesis asserts that the number of cointegrating vectors is equal to the rank of matrix; the alternative hypothesis is that the cointegrating vectors are less than the number of rank (Brooks, 2008: 351).

The maximum eigenvalues test is based on the premise that λ_i is the maximum or i -th eigenvalue of the matrix Π (Mtonga, 2011: 24; Enders, 2014: 378). The null hypothesis suggests that the number of cointegrating vectors is equal to the ranks; alternatively, the number of cointegrating vectors is greater than the ranks (Brooks, 2008: 352). In the event that the number of cointegrating vectors is greater or equal to the rank in the trace test, the testing has to be done in sequences until the rank is proven to be less than the cointegrating

vectors, in order for the null hypothesis of the maximum eigenvalues not to be rejected (Brooks, 2008: 352).

As argued by Bachmann (2012: 13), the advantage of the trace and maximum eigenvalue tests is that short- and long-term equilibrium relationships are not treated as mutually exclusive. An additional advantage of the Johansen approach is that hypotheses tests can be done on the variables with cointegrating relationships (Brooks, 2008: 356). Other approaches to cointegration estimation, such as the Granger causality test, can also be used. However, the limitation of the specific test is that it only identifies statistically significant regressors, without identifying any causal relationship among the variables or providing additional information.

3.4.3. Vector Error Correction Model

An error correction model is necessary when changes in the values of the regressors induce changes in the values of the regressand within two periods (t-1 and t), and when there is a disequilibrium that occurs during those periods (Brooks, 2008: 338). Since the sticky price model allows for the exchange rate to overshoot in the short run, an error correction model is necessary to control for the monetary shocks that induce changes in the rand/dollar exchange rate, in the short run. This implies that the Vector Error Correction Model will be restricted in the way that allows changes in monetary policy to have an immediate and full impact on the exchange rate, as per the basic premises of the sticky price model. The model used for cointegration analysis is called a Vector Error Correction model (VECM) and is usually derived from a VAR model, as illustrated in equation 5 in section 3.4.2 (Lütkepohl & Krätzig, 2004: 88; Bachmann, 2012: 21; Brooks, 2008: 350).

In relation to the model used in our study, assume our structural VAR model (equation 4), presented in a reduced form with all the variables, is represented in one vector “ X_t ”. Thus,

$$X_t = \{(m_t - m_t^*), \ln(y_t - y_t^*), \ln(\pi - \pi^*), (i_t - i_t^*), \ln(tsZA_t), \ln(VIX), \ln(e)\}.$$

The equivalent VECM model of the reduced form of the SVAR is then given by equation 6:

$$(6) \Delta X_t = \Pi X_{t-1} + \sum_{j=1}^p \Gamma_{p-1} \Delta X_{t-p+1} + \varepsilon_t.$$

where ΠX_{t-1} captures the long-run dynamics and $\sum_{j=1}^p \Gamma_{p-1} \Delta X_{t-p+1}$ captures the short-run dynamics between the rand dollar exchange rate and its determinants.

The shortcomings of interpreting VECM coefficients are that they do not always make theoretical sense, and their multitude in multivariate studies renders them cumbersome and difficult to interpret (Gil, BenKaabia & Chebbi, 2011: 110). Given the caution required when interpreting VECM results, two more methods used to investigate long–run relationships will be added in the study to substantiate the VECM results. These two methods are the Granger Causality Test and Variance Decomposition.

The Granger Causality test effectuated on a VECM proposes that taking variables into consideration, one variable at a time, is taken as a dependent variable (regressand) and others as independent variables (regressors), and it then looks at the causality between these variables (Brooks, 2008: 342). Once again, it is important to be cautious when interpreting the results of a Granger Causality test, because the ‘causality’ simply portrays a “*chronological ordering of movements*”, it is not that a variable ‘x’ causes movements in variable ‘y’ (Brooks, 2008: 312). This chronological ordering of movements simply implies that current or past values of a variable ‘x’ are correlated with current or past values in variable ‘y’.

While Granger Causality does not provide any information about the sign of coefficients in and the implication it has on the dynamics, the nature of the variables relationships or the longevity of a shock in the system. However, the Variance Decomposition does provide such information. The method shows how much of variance in a variable is explained by another variable, both in the short and long run (Brooks, 2008: 305). However, Brooks (2008: 301) highlights that Variance Decomposition results do not always provide the most accurate results because of large confidence bands and the ordering of variables that obstruct strong inferences from being made.

3.5 Diagnostic checks

A diagnostic check consists of evaluating the model to assess its goodness of fit (Gujarati, 2003: 846). The importance of such tests is to guarantee that the model will provide reliable results, from which correct inferences can be made (Lütkepohl & Krätzig, 2004: 125). These tests are effectuated on the error terms of the model. There are three types of checks conducted on the model, namely checks for the presence of serial autocorrelation, multivariate normality of residuals and heteroscedasticity.

The first check to be done on the model is to assess whether there is serial autocorrelation. Serial autocorrelation occurs when, in a given series, error terms are correlated, meaning that the current error term in time 't' (present) is affected by its lagged value in time 't-1' (past) (Gujarati & Porter, 2003: 442). As explained by Lütkepohl and Krätzig (2004: 128), and Brooks (2008, 140-143), serial autocorrelation can be tested using the Portmanteau, Durbin-Watson or Breusch-Godfrey LM tests. For the purpose of this study, the Breusch-Godfrey LM test will be used. The null hypothesis of the test suggests that the current error is not related to any of its lagged values (Brooks, 2008: 148).

The second check is the multivariate non-normality of residuals. A good model has normally distributed error terms, which leads to desired normally distributed coefficients (Brooks, 2008: 53). The test conducted on the model is the Bera-Jarque normality test. The test is based on the third (skewness) and fourth (kurtosis) moments of the distribution (Lütkepohl & Krätzig, 2004: 44). The null hypothesis suggests that the residuals are normally distributed, provided that the probability value is no greater than 0.05, the skewness is equal to zero and kurtosis is equal to three (Brooks, 2008: 163).

Lastly, we check for the presence of heteroscedasticity. There is heteroscedasticity in the model, when the variance of the error terms is not constant (Chan, 2002: 101). When error terms are not constant, as desired, it means that the errors are not following a random walk and they are likely to influence each other. The null hypothesis is that the variances of all the error terms are equal, thus homoscedastic (constant). The alternative hypothesis is that error terms are not constant, thus heteroscedastic.

According to Chan (2002, 100-101), Lütkepohl and Krätzig (2004: 44) and (Brooks, 2008: 135, 149, 163), there are implications involved in disregarding serial autocorrelation, multivariate non-normality and heteroscedasticity. Firstly, when serial autocorrelation is ignored, wrong inferences about variables and their relationships can be made. Secondly, when the non-normality of residuals is overlooked, wrong inferences about coefficients can be made. Lastly, not checking for heteroscedasticity means that the standard errors values could be wrong; this also leads to misleading inferences, similarly to the case of serial autocorrelation (Chan, 2002: 102).

3.6 Conclusion

This chapter served as a review of the econometric methods to study the relationship between the rand/dollar exchange rate and its determinants. There are different stages to the analysis. Firstly, models require be specifying and restricting in order to make econometric sense. A monetary approach to exchange rate determination, more precisely the sticky price model, is used to explore the variables dynamics.

In terms of the short-term dynamics, the Vector Autoregression (VAR) model is used. There are three types of VAR models: structural, reduced and recursive. For the purpose of the study, the structural VAR will be used as it makes allowances for economic theory to be the foundation used when explaining the relationships.

Long-term relationships are studied using cointegration tests. Before investigating the presence of long-term relationships, one has to conduct a stationarity test. Once the data are proven to be stable, the exploration of long-term relationships in the data can carry on. The first step is to establish how many long-term relationships exist using the Johansen test. Once the number of relationship has been established, one can proceed to running a Vector Error Correction (VECM) model. A VECM model captures and corrects any short-term disequilibrium and provides information about any existing long-run relationship among variables. The Granger Causality and Variance Decomposition methods will be added onto the VECM results in order to obtain accurate results and substantial inferences about the long run relationship between the exchange rate and its determinants. The last tests to conduct are diagnostic checks, which involve assessing whether the model is stable, good and fit the data.



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Chapter Four

4. Results

4.1 Introduction

The fourth chapter presents the results of the econometric tests used to analyse the relationship between the rand/dollar exchange rate and its determinants. The unit root test results discussed in Section 4.2 are an essential part of the econometric analysis, which is required before studying relationships. Following the unit root test results section are the results of the impulse response function in section 4.3. Section 4.3 provides the analysis of the short-run relationships of the exchange rate and its determinants using the impulse response functions. Section 4.4 then combines all the tests results for the long-run analysis of the model, precisely the cointegration model. Section 4.5 deals with the different diagnostic checks that were conducted to ensure that the model is stable and residuals are behaving as desired. Section 4.6 concludes the chapter.

4.2. Unit Root Test

Unit root testing is crucial in terms of long-term analysis (Mireku, Sarkodie & Poku, 2013: 37). This test consists of identifying whether the variables are stationary or not. As discussed in Chapter 3, it is preferable for the variables to be stationary (without a unit root). The Augmented Dickey-Fuller and the Phillips-Perron tests are used to assess the stationarity of the variables (Gujarati, 2003: 814-815). The null hypothesis of the test suggests that there is a unit root, this hypothesis is rejected when the probability value ' p ' is less than 0.05 (Brooks, 2008: 333-334).

Table 4.1 Stationarity Test - South Africa

	Levels		First Difference	
	ADF	PP	ADF	PP
Exchange rate	-2.295372	-2.084324	-10.81592*	-10.75733*
Prime rate	- 3.381339***	-2.993327	-7.027805*	-11.45404*
Industrial production	-2.088013	-3.425434**	-15.61345*	-23.02175*
CPI	-0.539607	-0.531352	-9.962991*	-10.16986*

10-year bond rate	-2.804072	-2.522878	-11.88144*	-11.48732*
Total shares	-2.796139	-2.439249	-11.68574*	-11.49142*

(Note: *, **, *** stand for 1%, 5% and 10% levels of significance)

Table 4.1 shows the stationarity test results for the South African data set in levels and first difference. All the variables for South Africa have a unit root in levels, given that for both the ADF and PP tests the probability values ' p ' of the variables are greater than 0.05. These results suggest that all the variables have a unit root, thus not stationary in levels. However, in first difference the variables are statistically significant at 1% level of significance and stationary in order $I(1)$.

Table 4.2 Stationarity test - USA

	Levels		First Difference	
	ADF	PP	ADF	PP
Fed rate	-1.973485	-2.158122	-7.366361*	-7.370813*
Industrial production	-3.020395	-2.206956	-3.748302*	-14.73105*
CPI	-2.305809	-2.196578	-9.918115*	-7.774246*
10-year bond rate	-4.112904**	-3.945327***	-12.42197*	-12.42197*
VIX	-3.543358**	-3.345587***	-15.10993*	-16.49658*

(Note: *, **, *** stand for 1%, 5% and 10% levels of significance)

In terms of the US data set shown in the above table, some variables are stationary both in levels and in first difference. The 10-year bond rate is stationary in levels. The rest of the variables are stationary only in first difference. All the variables are statistically significant at 1% in the first difference.

Table 4.3 Stationarity test for the sticky price model variables

	Levels		First Difference	
	ADF	PP	ADF	PP
(m-m̄)	-3.184262***	-2.768646	-6.602440*	-11.26763*
log(y/ȳ)	1.858425***	-3.085386	-17.74281*	-27.52902*
(π - π̄)	-10.32698*	-10.88206*	-15.61536*	-38.55250*
(i-i)	-2.501806	-2.174398	-12.35421*	-12.11801*

(Note: ' is representative of a foreign country's variable, the USA in this case. Additionally, *, **, *** on the ADF and PP values stands for 1%, 5% and 10% levels of significance)

The last set to undergo the stationarity test is the data used as per the sticky price model as discussed in chapter 2 and 3. The sticky price model takes into consideration the subtraction of a variable in the domestic country minus the variable of the foreign country, the resulting variable is then used for the computation. Table 4.3 shows that all the variables are not stationary in levels, except the inflation rate. Otherwise, all the variables are stationary in first difference.

Once the stationarity test has been completed, the succeeding tests consist of studying the long-term relationship between the rand/dollar exchange rate and its determinants. It is crucial to begin the analysis with the stationarity tests before moving to the cointegration tests, because as using non-stationary variables may lead to spurious regressions and erroneous inferences (Brooks, 2008: 139).

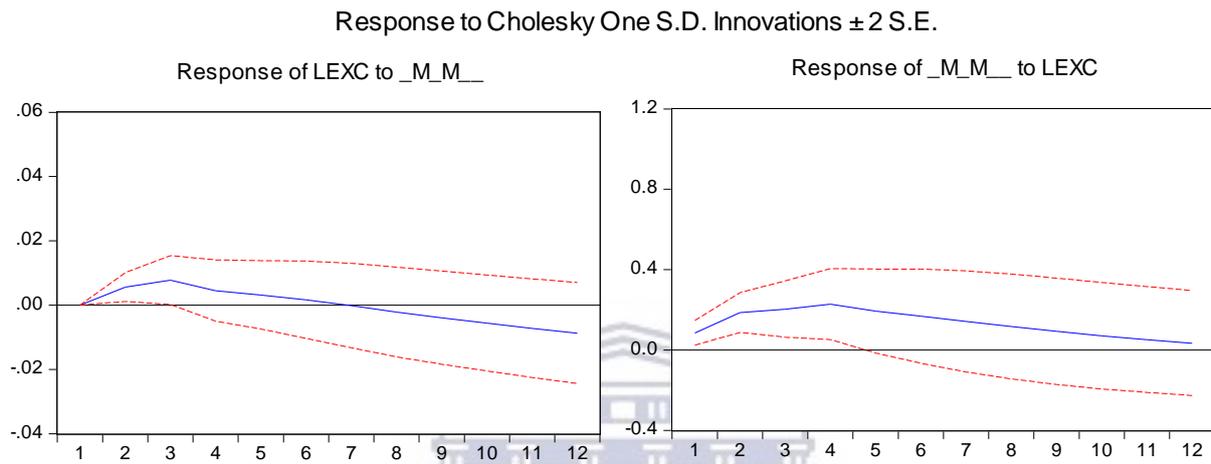
4.3. Impulse Response

As presented by Brooks (2008: 299), an impulse response function shows the responsiveness of the chosen regressand to shocks in the error terms of the regressors. Provided a unit shock in the error term of a variable, the impulse response function shows by how much and how long the innovation lasts in the system (Brooks, 2008: 299). The impulse response functions have been separated into four categories of variables: nominal sector, real sector, the financial sector and news.

4.3.1 Nominal sector variables

Figure 4.1 shows the longevity and the effect of a one standard deviation shock in the exchange rate error term has on the monetary policy interest rates of both countries. Concurrently, the impulse response also assesses the effect that one standard deviation shock in monetary policy interests rates error term has on the exchange rate.

Figure 4.1 Monetary Policy



The two quadrants in Figure 4.1 show the relationship the exchange rate has with monetary policy.

The first quadrant shows the response of the exchange rate to changes in monetary policy. The results show that a one standard deviation shock in the monetary policy interest rates leads to 0.01% depreciation in the exchange rate starting in the second month; this suggests that the variables have an insignificant positive relationship. The positive relationship between the variables means that when monetary policy interest rates of a country rise, the value of its exchange rate depreciates for the first three months. This implies that should the South African prime rate rise, the value of the rand against the dollar depreciates. Despite the immediate depreciation of the currency, this fall in the value of the rand against the dollar is negligible. These results showing a depreciation of the rand against the dollar and a succeeding appreciation of the rand are in line with the theory discussed in Chapter 2. The theory suggests that following a monetary policy expansion, the exchange rate overshoots in the short run; hence the depreciation is first accompanied by an appreciation, which is the result of a rise in prices and export demand (Isard, 1995: 121-123).

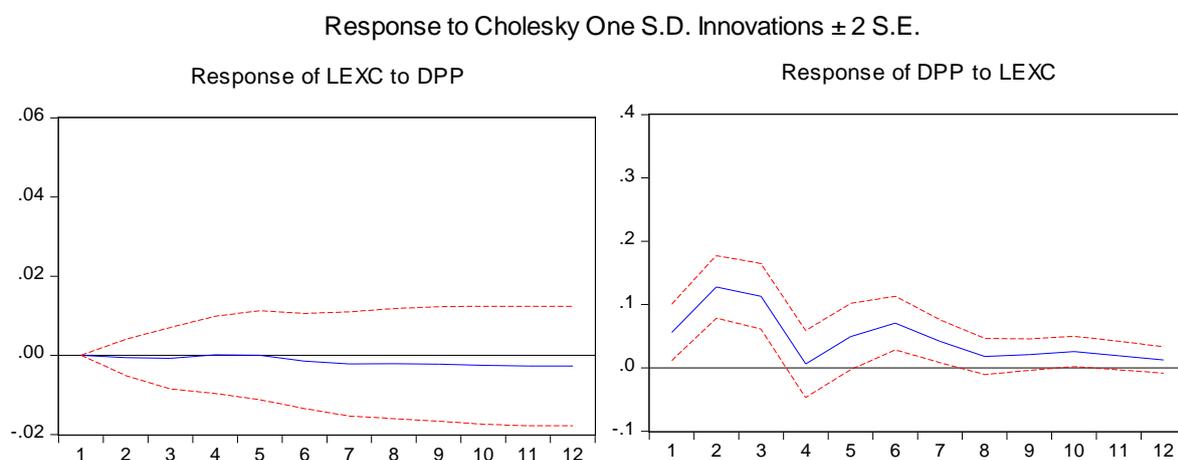
While our results show a relatively weak positive relationship between monetary policy and the exchange rate, Faust and Rogers (2003: 1422) found opposing results. The authors ascertained that changes in the monetary policy rates do not induce significant changes in the exchange rate, in the short run (Faust & Rogers, 2003: 1422). Similarly, De Bruyn, Gupta and Stander (2015: 30) found that monetary models were not empirically valid in the short term; hence a change in the monetary policy is not expected to induce a significant change in the exchange rate.

The second quadrant illustrates the effect of a change in the exchange rate on policy interest rates. As seen in the graph, a one standard deviation in the rand/dollar exchange rate leads to a 0.3% deviation in the monetary policy interest rates in the fourth month. The results suggest that the effect of a change in the exchange rate amplifies in the short run until the shock weakens at the fourth lag. The shock does not persist in the system.

The evidence proves that there is a definite bilateral positive relationship between the exchange rate and the monetary policy interest rates, in the short run. Nonetheless, the effect of a change in the exchange rate is greater than the effect of a change in the monetary policy on the exchange rate. This bilateral relationship suggests that when the rand/dollar depreciates, the monetary policy interest rates rise consequently. This rise in the policy rates is justifiable in the instances that the Central Banks of the countries desire to counteract a predictable rise in the inflation rate induced by the increase in export demand, export output and prices (Taylor, 1993: 24).

Figure 4.2 illustrates the relationship between the CPI indices ($CPI_{SA} - CPI_{US}$) between both countries and the rand/dollar exchange rate.

Figure 4.2 Inflation



The two quadrants illustrated in Figure 4.2 show the relationship between the rand/dollar exchange rate and the CPI indices of both countries.

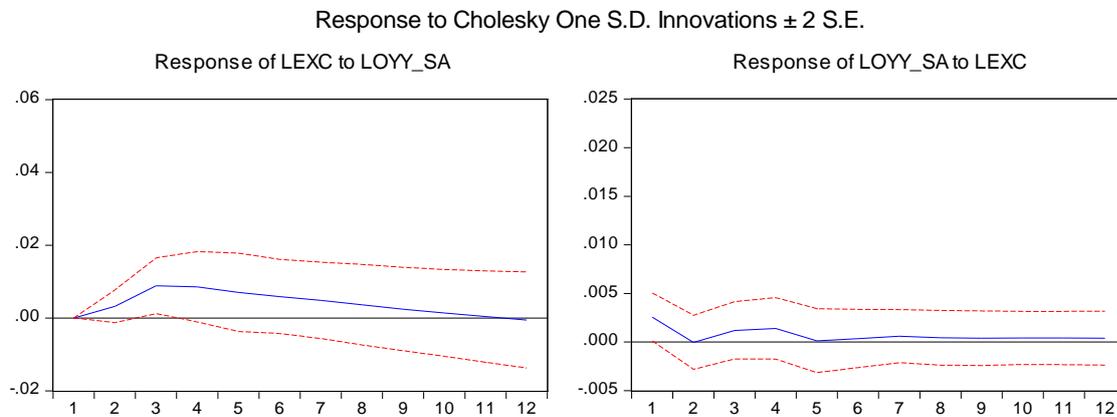
The first quadrant shows that a change in the CPI indices does not impact on the rand/dollar exchange rate, given that the change in the indices leads to 0.00% change in the exchange rate over a 12-month period. Inflation does not have any significant, positive or negative impact on the exchange rate. These findings contradict the results of Sichei, Gebreselasie and Akanbi (2005: 15-17), who argue that an increase in prices leads to the rand/dollar depreciation over five quarters. Bhundia and Gottschalk (2003: 7) also found that following a rise in prices the exchange rate immediately appreciates.

The second quadrant suggests that a change in the exchange rate leads to a significant 10% change in the price level; the effect of which becomes mostly significant in the first three months. The rand/dollar exchange rate has a positive impact on the CPI indices only for the first few months, after which the impact slowly dissipates. This means that a depreciation of the rand against the dollar is prone to increase the price indices in the first quarter. The results are in line with the dynamics of the sticky price and the current account balance models, as prices adjust slowly to a change in the exchange rate. According to theoretical fundamentals, the rise in prices is due to the growing demand for domestic goods caused by the initial currency depreciation (Mussa, 1977: 97-98). Mussa (1977) and Taylor (1995) further argue that given a change in the exchange rate, prices adjust slowly before they return to their equilibrium state.

4.3.2 Real sector variables

Figure 4.3 demonstrates the relationship between industrial production (output and business cycle proxy) and the rand/dollar exchange rate.

Figure 4.3 Industrial Production



The first quadrant suggests that changes in output have a positive and relatively insignificant effect on the exchange rate. A one standard deviation in the industrial production index for both countries positively affects the exchange rate; this means that a rise in output, although small, depreciates the rand/dollar exchange rate. Nonetheless the shock does not remain in the system for a long time.

Likewise, the second quadrant also suggests that depreciation of the rand/dollar exchange rate leads to some insignificant negative change of -0.00025% in the industrial production indices of both countries. This evidence suggests that there is a statistically insignificant relationship between the rand/dollar exchange rate and output, which is in line with the main assumptions of the sticky price model. As discussed in chapter two, the main assumption of the sticky price model is that changes in prices cause short-term deviations in the exchange rate, but the goods market does not immediately adjust to the shocks (Afat, Gómez-Puig & Sosvilla-Rivero, 2015:7).

4.3.3 Financial sector variables

The dynamics analysed in this section are the relationship between the exchange rate and the 10-year bond rate spread, and the relationship between all share indices and the exchange rate.

Figure 4.4 10year Bond rate (T-Bill) spread

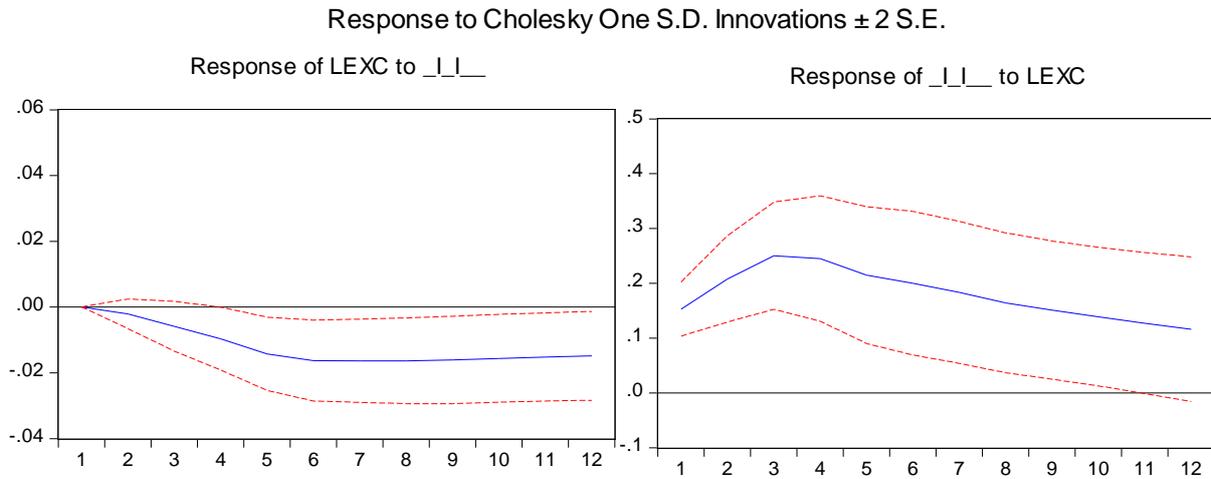
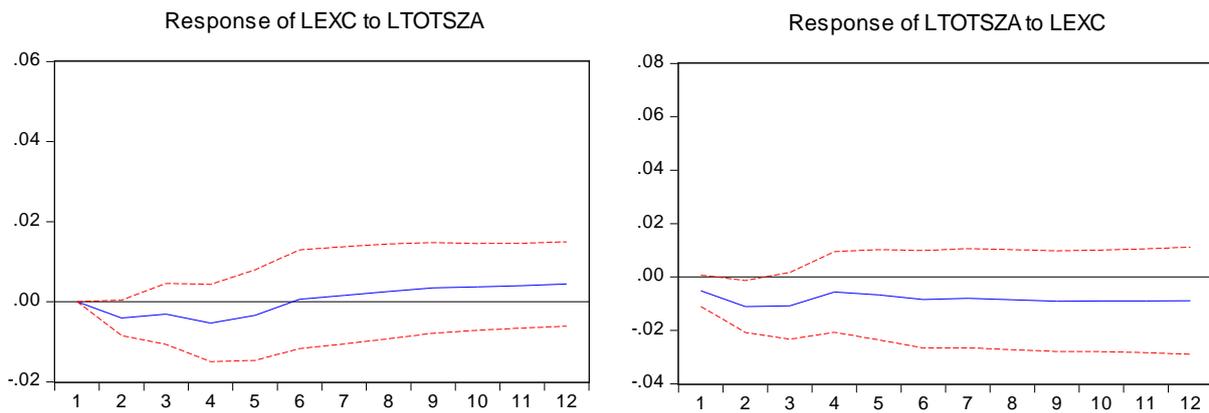


Figure 4.4 shows the response of the exchange rate to changes in the long-term rate spread, and vice versa. The first quadrant suggests that the exchange rate responds negatively to a change in the 10-year bond rates of both countries. Indeed, an increase in the spread leads to a statistically insignificant appreciation of the rand against the dollar. Gossel and Biekpe (2012: 111) offer a similar view, as their results suggest that an increase in the long-term interest rates differential should lead to a currency appreciation.

In contrast, the results of the second quadrant show that a unit standard deviation in the exchange rate leads to a positive and significant change in the 10-year bond rate. A change in the rand/dollar exchange rate leads to 0.25% rise in the yield for three months, until the innovation starts decelerating after the third month. The evidence suggests that when the rand/dollar depreciates, the 10-year bond rate rises immediately and significantly. Following a fall in the value of the currency, the bond rate immediately increases but decelerates by the second month. The rise in the interest rate relates to the lower opportunity cost of buying a long-term bond, whilst the deceleration is due to expected higher inflation which erodes the return on the bond and inevitably decreases the 10-year bond rate over time (Gossel & Biekpe, 2012: 111).

Figure 4.5 Total Shares Index

Response to Cholesky One S.D. Innovations ± 2 S.E.



The above Figure 4.5 illustrates the relationship of the rand/dollar exchange rate with South Africa’s total share index, which serves as financial market indicator.

The first quadrant suggests that a rise in the total share index of South Africa leads to rand/dollar appreciation followed by depreciation by the 6th month. The response of the exchange rate is fairly insignificant (-0.0001%) and is short lived. Similarly, as seen in the second quadrant, a one standard deviation in the rand/dollar exchange rate leads to a negative and insignificant change in the total share index of South Africa. Hence, there is no significant relationship between the rand/dollar exchange rate and the total share index of South Africa. These findings do not correspond with the results of the study conducted by Gossel and Biekpe (2012: 111). These authors found that after 1995, an increase in equity returns induced a significant appreciation of the rand/dollar exchange rate following a rise in equity purchase (Gossel & Biekpe, 2012: 111).

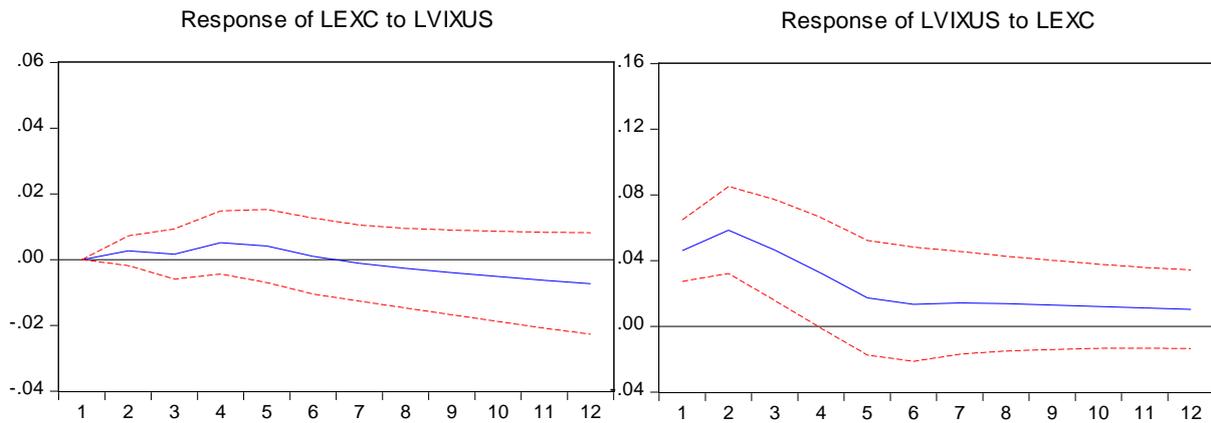
Ultimately, the combined evidence shown in Figure 4.5 suggests that there is a negative and statistically insignificant relationship between the rand/dollar exchange rate and the total share indices of South Africa.

4.3.4 News variable

The volatility (VIX) index is used as proxy for news in the financial market. The index measures the level of uncertainty created by developments in the financial markets. The developments include news from the policy side, nominal and real sector and other news such as natural disasters etc. Following the findings of Fedderke and Flamand (2005: 13), indicate that news from the USA affects the rand/dollar exchange rate more than news from South Africa. The aim of this section is to assess whether these findings are true.

Figure 4.6 News Variable

Response to Cholesky One S.D. Innovations ± 2 S.E.



The above Figure 4.6 indicates evidence about the relationship between the rand/dollar exchange rate and the news variable.

Results in the first quadrant suggest that a unit change in VIX leads to an insignificant depreciation in the rand/dollar followed by an appreciation in the 6th month. The effect of depreciation in the rand/dollar exchange rate on the index remains greater than the effect of VIX on the exchange rate. Although the shock decelerates after three months, there is an insignificant rise in the index following a depreciation of the rand/dollar exchange rate. This evidence suggests that the volatility in the financial markets does not lead to a change in the exchange rate, while an appreciation of the exchange rate leads to more volatility in the financial market.

The above evidence suggests that there is a unilateral relationship between the rand/dollar exchange rate and VIX index. This goes against the Efficient Market Hypothesis model which suggests that news does drive the exchange rate. Similarly, it also goes against the findings of Fedderke and Flamand (2005:7), who ascertained that news from the real, nominal and political side of the economy affected the rand/dollar exchange rate; although more attention is devoted to news from the USA than local South African news.

In term of short-term dynamics, there were no instances where there was a strong bilateral relationship between the rand/dollar exchange rate and its determinants. In terms of the nominal side of the economy, there is only a unilateral significant relationship. Depreciation in the rand/dollar does create a significant increase in the policy rate differential. The same can also be said for the inflation rate differential; although gradual, the impact of depreciation on the rand/dollar exchange rate has a greater impact on the prices than the opposite case.

There was no significant relationship between output and the exchange rate. On the other hand, there is only one significant unilateral relationship between the exchange rate and the financial markets variables. The only unilateral relationship is where the rand/dollar depreciation in the exchange rate leads to a significant but short lived rise in the 10-year bond rate. Lastly, in terms of news, there a short-lived and insignificant relationship between the news proxy and the exchange rate.

4.4 Cointegration Test Results

Lütkepohl and Krätzig (2004: 88) refer to cointegration as the econometric analysis of long term relationships of time series variables. The tests in this section have to do with identifying the number of existent long-term relationships in the data. The results from the tests are presented in a sequential manner. Firstly, a lag length structure test is done in order to choose the appropriate lag. Secondly, the Johansen test, comprising of the trace and maximum eigenvalues tests, will inform us about the number of long-run relationships there are in the model. Lastly, the results from the Vector Error Correction model will be discussed.

4.4.1 Lag length structure

The selection of appropriate lags for a model is an essential step in the analysis. Choosing the appropriate lag length enhances the fit and goodness of the model, which helps to make correct inferences (Brooks, 2008: 304). Two of the main information criteria used are the Akaike and Schwarz Information Criteria. The lag length with the lowest value in terms of these criteria is usually the advised lag length to impose on the model (Gujarati, 2003: 537).

Table 4.4 Lag Length Structure

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-712.6035	NA	1.34e-06	6.340119	6.445734	6.382736
1	1284.311	3853.076	4.71e-14	-10.82212	-9.977198*	-10.48118
2	1374.751	168.9293	3.27e-14	-11.18724	-9.603010	-10.54798*
3	1431.313	102.1598	3.07e-14*	-11.25386*	-8.930326	-10.31628
4	1474.737	75.75230	3.24e-14	-11.20473	-8.141888	-9.968828
5	1527.295	88.44533*	3.17e-14	-11.23608	-7.433929	-9.701854
6	1553.815	42.99324	3.92e-14	-11.03802	-6.496563	-9.205474
7	1585.323	49.13622	4.66e-14	-10.88390	-5.603144	-8.753040
8	1617.574	48.30458	5.54e-14	-10.73633	-4.716264	-8.307146
9	1644.062	38.04095	6.98e-14	-10.53799	-3.778620	-7.810487
10	1686.935	58.92641	7.68e-14	-10.48401	-2.985329	-7.458182
11	1725.955	51.22488	8.84e-14	-10.39608	-2.158096	-7.071934
12	1760.460	43.16932	1.07e-13	-10.26837	-1.291081	-6.645904

Since we are using data with a monthly frequency, we selected a lag order of 8 to assess what would be the appropriate lag order. The information criteria reported are the Akaike and Schwarz information criteria. According to Mireku, Sarkodie and Poku (2013: 38), the Akaike Information Criterion is the leading information criterion and the most commonly used to select a lag length. As seen in the above Table 4.4, the Akaike Information Criterion suggests that the maximum lags to use should be two. On the other hand, the Schwarz Information Criterion suggests that a maximum lag of one should be selected. However, the final decision was to select two lags, as per the AIC criterion. Unfortunately, due to autocorrelation issues in the model, the number of lags had to be increased to four in order to counteract the problem of serial correlation.

4.4.2 Johansen Test Results

The Johansen test, which is comprised of the trace and maximum eigenvalue tests, provides evidence of the number of long-term relationships evident in the data.

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.227503	168.5518	125.6154	0.0000
At most 1 *	0.163933	108.4082	95.75366	0.0051
At most 2	0.112928	66.69046	69.81889	0.0866
At most 3	0.091979	38.77018	47.85613	0.2695
At most 4	0.053261	16.28856	29.79707	0.6918
At most 5	0.015020	3.535970	15.49471	0.9373
At most 6	4.15E-05	0.009661	3.841466	0.9214

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.227503	60.14367	46.23142	0.0010
At most 1 *	0.163933	41.71770	40.07757	0.0324
At most 2	0.112928	27.92028	33.87687	0.2172
At most 3	0.091979	22.48162	27.58434	0.1967
At most 4	0.053261	12.75259	21.13162	0.4753
At most 5	0.015020	3.526309	14.26460	0.9057
At most 6	4.15E-05	0.009661	3.841466	0.9214

Table 4.5 shows the results of the Johansen test, using a restriction of four lags. The trace test suggests that there are at most two cointegration relationships in the data. Similarly, the maximum eigenvalue test suggests that there are two cointegration relationships at most. Following the results of the Johansen test, we chose to restrict the Vector Error Correction model to a rank of two, which implies that there are two presumable long-term relationships in the model.

4.4.3 Vector Error Correction Model Results

The Vector Error Correction model is used to examine long-term relationships among the variables (Lütkepohl & Krätzig, 2004: 88). The VECM short and long term coefficients, α and β respectively, are interpreted differently (Brooks, 2008: 352). In terms of the short-run dynamics, the short run coefficients show how fast the variables adjust to a shock and the error correction is considered significant at a 0.05 level of significance, if the sign of the alpha coefficients is negative and the error term is below the 5% confidence band (Gil, BenKaabia & Chebbi, 2011: 111-114). For the long-run dynamics, the sign of the coefficients has to be inverted before making any inferences about a possible cointegration relationship. The sign of the long-run coefficients then informs us about whether the relationships are negative or positive, and these relationships are considered significant only if the standard error term is below the 5% confidence band (Gil, BenKaabia & Chebbi, 2011: 111-117).

Furthermore, one can use theory to restrict cointegrating vectors to a certain values in order to obtain more accurate results (Brooks, 2008: 355). Since the sticky price model is the theoretical basis of our methodology, the long-term coefficients $\beta_{(1,1)}$ and $\beta_{(2,1)}$ of the exchange rate and the monetary policy interest rates $\beta_{(1,2)}$ and $\beta_{(2,2)}$ are restricted to 1 and 0 respectively, in order to represent instances where a change in the exchange rate does not impact on the monetary interest rates, should the policy rates not respond to the rand/dollar shock as a result of the slow adjustment of prices. Alternatively, the exchange rate long term coefficient $\beta_{(2,1)}$ would be restricted to 0 and the monetary policy rates $\beta_{(2,2)}$ to 1, should the monetary policy respond immediately and stand as correlated to the exchange rate in the long term.

Table 4.5 Vector Error Correction Model- Short Run(r=2)

	<i>exc</i>	<i>(m-m)</i>	<i>(y/y)</i>	<i>($\pi - \pi'$)</i>	<i>(i-i)</i>	<i>totsZA</i>	<i>vix</i>
Cointeq1	-0.008540*	0.013837***	-0.003257*	-0.459053***	0.276421	-0.022788**	-0.032455**
Cointeq2	-0.000295*	0.017826**	0.000321*	0.012192**	-0.048547**	0.004911*	0.001809*

(Note: *, **, *** represent 1%, 5% and 10% level of confidence)

Table 4.6 provides the values of the alpha coefficients, which represent the variables speed of adjustment. In the first cointegration equation, only the exchange rate, the output and price differentials, the total share and the news proxy have the desired negative signs to confirm a short run significant relationship. The strongest short-run relationship exists between the

exchange rate and itself and the output differential at 1% level of confidence. These findings suggest that the exchange rate adjusts to its own shock at 0.008% per month, which is quite slow. The same applies to the adjustment of the exchange rate to a shock in output, which amounts to 0.003%; this is quite slow too. This is expected in a sticky price model where it takes time for variables to adjust to a change in prices. Additionally, a weak cointegration exists between the exchange rate and the price differential at 10% level of confidence. However, the exchange rate adjusts quite rapidly to changes in the price differentials at a speed of 0.46% per month.

The second cointegration equations the exchange rate and the 10-year bond rate differential have the desired coefficients signs. Although the relationship between the current value of the exchange rate and its past values is strongly significant, the variable adjusts even slower to its own shocks at a speed of 0.0003%. While, the relationship between the exchange rate and the 10-year bond rate differential is relatively significant, the rand/dollar adjusts fairly slowly to deviations in the 10-year bond rate at a 0.048% speed of adjustment per month. Other variables do not have the desired coefficients signs although they are significant at 1% and 5% levels of confidence.

Table 4.6 Vector Error Correction Model - Long Run(r=2)

	exc	(m-m)	(y/y)	($\pi - \pi$)	(i-i)	totsZA	vix	C
Cointeq1	1	0*	- 4.019459	2.814403	-0.157618**	- 0.559971	- 0.559971	2.580684
Cointeq2	0*	1	16.76103	17.75178	0.104604	- 6.981987	-5.584456	20.20924

(Note: *, ** stand for 1% and 5% level of confidence)

Table 4.7 provides the values of the long-term beta coefficients. The first cointegration equation is restricts the exchange rate long-run coefficient to 1, while the monetary policy rate differential is restricted to 0 for instances where the prices are sticky. In the first long-run equation only the 10year bond rate spread has a long-term relationship with the exchange rate at 5% level of significance. The equation suggests that a 1% increase in the 10-year spread leads to 0.15% rand/dollar depreciation. All other variables do not have a statistically significant long-term relationship with the rand/dollar.

The second cointegration equation shows the relationship between the rand/dollar exchange rate and its determinants. The exchange rate long-run coefficient is restricted to 0, while the monetary policy differential is restricted to 1 to illustrate the case of non-sticky prices. In this instance the exchange rate does not have any long-run relationship with any of its determinants.

Because of the weakly significant results with the model restricted to a rank of 2, we decided to re-run the model with a rank of 1.

Table 4.7 Vector Error Correction Model - Short run (r=1)

	<i>exc</i>	$(m-\dot{m})$	(y/\dot{y})	$(\pi - \dot{\pi})$	$(i-i)$	<i>totsZA</i>	<i>vix</i>
Cointeq1	-0.012137*	0.118964	-0.002144*	-0.491741***	0.060237***	-0.000236*	-0.029347**

(Note: *, **, *** represent 1%, 5% and 10% level of confidence)

Table 4.8 shows the adjustment speed of the exchange rate to its determinants and its own short-run deviations. The exchange rate, the output and price differentials as well as the total share and the news proxy have desired signs. There is a strongly significant relationship between the exchange rate and the output differential and the total share index, although the exchange rate responds faster to its own deviations relative to the other two variables. Similarly to the model restricted to two ranks, the exchange rate responds rapidly to changes in the prices, at a 0.49% speed of adjustment per month, albeit it is weakly significant at 10% level of significance.

Table 4.8 Vector Error Correction Model- Long Run (r=1)

	<i>exc</i>	$(m-\dot{m})$	(y/\dot{y})	$(\pi - \dot{\pi})$	$(i-i)$	<i>totsZA</i>	<i>vix</i>	<i>C</i>
Cointeq1	1.000000	0.038999**	-4.673121	2.122103	-0.161698**	-0.287681	0.027758	1.792545

(Note: ** represents 5% level of significance)

Table 4.9 illustrates the long-run relationship between the rand/dollar exchange rate and its determinants at 5% level of significance. The rand/dollar exchange rate is significantly related to monetary policy and 10-year bond rate differentials. The results suggest that in the long run the exchange rate is highly correlated to its past values. While the exchange rate has a positive relationship with the policy interest rates, it has a negative relationship with the 10-year bond rates. A 1% increase in the policy rates leads to 0.04% rand/dollar depreciation in the long run. A 1% increase in the 10 year bond rate differential leads to a 0.16%

appreciation of the rand/dollar. These results concur with the premises of the sticky price model, which suggests that the exchange rate is correlated to nominal values.

4.4.4 Granger Causality and Variance Decomposition

Granger Causality and the Variance Decomposition methods are included in the long-run analysis to complement the VECM.

Table4.9 Granger-Causality

Excluded	Chi-sq	df	Prob.
D(_M_M_)	12.69335	5	0.0264
D(LOYY_SA)	11.16573	5	0.0482
D(DPP)	4.266544	5	0.5117
D(_I_I_)	15.87150	5	0.0072
D(LTOTSZA)	7.680940	5	0.1747
D(LVIXUS)	1.310481	5	0.9338
All	54.81969	30	0.0037

Table 4.10 results report the possible long-run relationships between the rand/dollar exchange rate and its determinants at a 0.05 level of significance, using the Granger causality test. The exchange rate is treated as the ‘dependent’ variable. At a 0.05 level of significance, monetary policy rate and output Granger cause movements in the rand/dollar, so as the 10 year bond rate. The new insight provided by the Granger causality test is that output and the rand/dollar have a long-run relationship; this was not found by simply interpreting the VECM coefficients. Therefore, one could say that the rand/dollar is not simply affected by nominal variables but by real values too. These results coincide with the findings of De Bruyn, Gupta and Stander (2015), which suggest that the rand/dollar is cointegrated with monetary policy rates and output in the long run.

Table4.10Variance Decomposition

Period(t)	S.E.	LEXC	_M_M_	LOYY_SA	DPP	_I_I_	LTOTSZA	LVIXUS
1	0.032849	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.056493	96.48820	1.583335	0.363504	0.010885	0.395269	1.123120	0.035686
3	0.073584	92.27256	3.179545	1.508025	0.008003	1.381406	1.583783	0.066677
4	0.088183	89.67486	3.172076	1.475222	0.019872	2.720383	2.618418	0.319171
5	0.101455	87.88748	2.901037	1.213338	0.023827	4.529089	2.886013	0.559217
6	0.113052	86.57076	2.715577	0.980681	0.144931	6.151752	2.889475	0.546820
7	0.123143	85.47505	2.606128	0.984770	0.376952	7.068981	3.021870	0.466250
8	0.132185	84.64270	2.414435	1.085641	0.827823	7.492208	3.131185	0.406008
9	0.140668	84.19161	2.213313	1.146128	1.345470	7.657759	3.087056	0.358665
10	0.148829	83.90770	2.074082	1.275978	1.747062	7.644534	3.020317	0.330323
11	0.156743	83.74781	1.935305	1.448804	1.994146	7.613670	2.924332	0.335937
12	0.164361	83.64782	1.818091	1.640329	2.165000	7.600525	2.777432	0.350806

Variance decomposition results provide an insight into how much the movements in the rand/dollar exchange rate are explained by its determinants over a period of time. As seen in Table 4.11, the exchange rate movements are largely explained by their past values with a variance of 92% in the third month (short run). Although, variations in the exchange rate are largely explained by its own movements over time, the values decrease over time. Hence at the 12th month (long run), 83% of the rand/dollar variation can be explained by its past values.

Other variables seem to weakly explain the variation of the rand/dollar over time. The 10-year bond rate differential seems to be the only variable to explain movements in the exchange rate with values increasing overtime and amounting to 7% in the 12th month. Although almost insignificant, the policy rate differentials and the total share account for 3% of the rand/dollar movements; these values accelerate in the medium term but fall after that , showing a weak link between these variables and the rand/dollar exchange rate. These results are in line with the findings of Bhundia and Gottschalk (2003), who found that the financial variables, followed by nominal variables are the main sources of exchange rate volatility especially in the first months.

The results we obtained from the long term analysis are in line with the theory and are validated by the empirical findings of similar studies such as those by Bhundia and Gottschalk (2003) and De Bruyn, Gupta and Stander (2015). In the short run the exchange rate was found to be affected by output differential, total shares index and its own deviations. However, this adjustment back to its long-term equilibrium value is very slow, which is expected in a scenario where prices are sticky.

In terms of the long run, the exchange rate was found to be cointegrated with the 10-year bond rate and the momentary policy rate differentials. These results correspond to the basic premises of the sticky price, which suggests that the exchange rate's current and past values relate to nominal and financial variables in the long run. Furthermore, as Gossel and Biekpe (2012) argue the association of the exchange rate and financial variables intensified after 1995, as the rand/dollar determinants changed from 'commodity' to 'equity' prices.

These VECM results were substantiated with the Granger Causality and Variance Decomposition test results. The Granger Causality test indicated that the exchange rate is

relates to monetary policy, output and the 10-year bond spread in the long run. The Variance Decomposition results suggested that the exchange rate is mostly related with its own past values, and weakly related to financial variables and the monetary policy rate.

Ultimately, the results indicate that a rise in the USA or South African policy rate, which would widen the gap between these rates, would lead to a depreciation of the rand/dollar. Similarly, a rise in the 10-year bond rate of South Africa or the USA is likely to result in the rand/dollar appreciation. The other variables such as the total shares and output do have a long-run relationship with the rand/dollar; however, the nature and direction of the relationship is not clear.

4.5 Diagnostic Check Results

Diagnostic checks assess the stability and the fit of the model. Three tests are conducted to ensure that there is no autocorrelation, heteroscedasticity in the model, and nonnormality.

4.5.1 Autocorrelation LM Test

Testing for multivariate autocorrelation is necessary to ensure that the error terms are not serially correlated. The null hypothesis of the Breusch-Godfrey test for autocorrelation assumes that there is no serial correlation of any order (Gujarati, 2003: 473).

Table 4.11 Autocorrelation LM Test Results

Lags	LM-Stat	Prob
1	34.20411	0.9462
2	43.21567	0.7057
3	35.12052	0.9322
4	52.04325	0.3563
5	43.59963	0.6911
6	43.70029	0.6872
7	41.21155	0.7777
8	61.34432	0.1110
9	37.24982	0.8905
10	40.40769	0.8040
11	54.66911	0.2680
12	41.25261	0.7763

(Probs from chi-square with 49 df.)

The null hypothesis of the residual serial correlation test suggests that, at a 0.05 level of significance, the error terms are serially correlated (Lütkepohl & Krätzig, 2004: 128). As seen in Table 4.7, at the second lag we fail to reject the null hypothesis at a 0.05 level of significance; this is as the probability values of the second lag (0.2817) are less than 0.05. Thus the error terms are not serially correlated at a lag order of 2.

4.5.2 Heteroscedasticity Test

The heteroscedasticity test illustrates the variance of the error terms. The aim of the test is to guarantee that the residuals are homoscedastic (have a constant variance). Residuals are homoscedastic when the probability values are above 0.05 (Brooks, 2008: 135-138).

Table 4.12 Heteroscedasticity Test Results

Chi-sq	df	Prob.
2180.214	1960	0.0003

The residuals are heteroscedastic at a 0.05 level of significance, given that the probability values 0.0003 are less than 0.05. According to Chan (2002: 101), and echoed by Sreedharan (2004:10), the presence of heteroscedasticity in financial market variables such as exchange rate, stock and bond prices is common, even if the variables follow a stationary process and are integrated in the first order. The reason for the presence of heteroscedastic error terms is that changes in the dependent variable tend to be 'clustered'. This clustering of changes is normal when it comes to the behaviour of exchange rate movements; given that during times of volatility large fluctuations may be followed by large fluctuations, and as the market stabilises small changes would be followed by small changes (Chan, 2002: 102). Therefore, the presence of heteroscedasticity is not reason enough to discard our model.

4.5.3 Normality Test

When performing the normality test, the Jarque-Bera test of normality is applied (Gujarati, 2003: 476). The Jarque-Bera test for nonnormality is based on skewness and kurtosis (the third and fourth moments) of the residuals (Lütkepohl & Krätzig, 2004: 45; Mills, 1999: 224-225). The null hypothesis of the Jarque-Bera test suggests that the residuals are normally distributed at a 0.05 level of significance (Brooks, 2008: 163).

Table 4.13 Normality Test Results - Jarque Bera

Component	Jarque-Bera	df	Prob.
1	76.66143	2	0.0000
2	2884.140	2	0.0000
3	20.79544	2	0.0000
4	0.067099	2	0.9670
5	22.95400	2	0.0000
6	16.90088	2	0.0002
7	8.761155	2	0.0125
Joint	3030.280	14	0.0000

At a 0.05 level of significance, a large Jarque-Bera statistical value showing large deviation from normality, with probability values greater than 0.05, requires the null hypothesis to be rejected (Mills, 1999: 224). As shown in Table 4.9, the null hypothesis is rejected at a 0.05 level of significance, since the probability values are less than 0.05.

Although, the results suggest that residuals are not normally distributed, the model will not be discarded since nonnormality does not compromise the accuracy of the results and the validity of the inferences (Lütkepohl & Krätzig, 2004: 46, 130). Both Mills (1999: 223) and Brooks (2008: 164) point out that the nonnormality of residuals is a common feature of financial markets variables such as the exchange rate. Mills (1999: 225) further argues that the only way to solve the issue of nonnormality is to add dummy variables or apply a GARCH model. However GARCH models are mostly concerned with measuring the volatility of variables (Chan, 2002: 153). Since our study does not measure the volatility of the exchange rate but its relationship with its determinants, the presence of nonnormality in the error terms will pose no threat to the exactitude of the results.

4.5.4. Model stability

Figure 4.10 and Table 4.13 and both portray the stability of the model. An autoregressive model is deemed stable when the inverse roots satisfy the invertibility condition. The invertibility condition proposes that polynomial roots should not be explosive and converge towards zero, whilst inverse roots should lie within the circle for the model to be stable (Brooks, 2008: 223).

As seen in the Figure 4.7 below there are no roots lying outside the circle, suggesting that the model we are using is stable and accurate inferences can be made from it.

Figure 4.7 Inverse Roots of AR Characteristic Polynomial

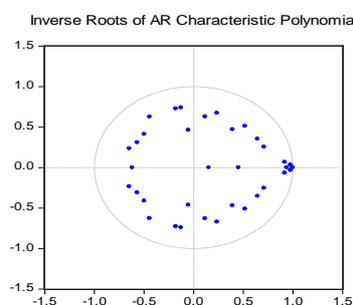


Table 4.14 Roots of Characteristic Polynomial

Roots of Characteristic Polynomial
Endogenous variables: LEXC _M_M_ LOYY_SA DPP _I_I_
LTOTSZA LVIXUS
Exogenous variables: C
Lag specification: 1 5

Root	Modulus
0.999589	0.999589
0.976684 - 0.033357i	0.977253
0.976684 + 0.033357i	0.977253
0.940057	0.940057
0.918935 - 0.066039i	0.921305
0.918935 + 0.066039i	0.921305
-0.441628 - 0.626849i	0.766796
-0.441628 + 0.626849i	0.766796
0.711517 - 0.253317i	0.755266
0.711517 + 0.253317i	0.755266
-0.125327 + 0.740572i	0.751102
-0.125327 - 0.740572i	0.751102
-0.179041 + 0.727149i	0.748866
-0.179041 - 0.727149i	0.748866
0.645089 - 0.353640i	0.735663
0.645089 + 0.353640i	0.735663
0.518453 - 0.510750i	0.727776
0.518453 + 0.510750i	0.727776
0.236341 + 0.671579i	0.711952
0.236341 - 0.671579i	0.711952
-0.648522 - 0.234096i	0.689479
-0.648522 + 0.234096i	0.689479
-0.568517 - 0.309424i	0.647267
-0.568517 + 0.309424i	0.647267
-0.496771 - 0.412211i	0.645522
-0.496771 + 0.412211i	0.645522
0.117653 + 0.628750i	0.639663
0.117653 - 0.628750i	0.639663
-0.617249	0.617249
0.392252 + 0.470054i	0.612219
0.392252 - 0.470054i	0.612219
-0.051411 - 0.462380i	0.465229
-0.051411 + 0.462380i	0.465229
0.453309	0.453309
0.154364	0.154364

No root lies outside the unit circle.
VAR satisfies the stability condition.

Similarly, Table 4.15 suggests that there are no roots lying outside the unit circle and the model used to investigate the relationship between the rand/dollar exchange rate and its determinants, is stable and can deliver correct inferences.

4.6 Conclusion

The fourth chapter presented the results of the different methods and tests used in the analysis of the short- and long-run dynamics between the rand/dollar and its determinants. The

structural VAR was chosen as a standard model for the study, since it is as it is the most appropriate and efficient model used to study structural relationships.

While the variables considered for South Africa had a unit root in levels, they were stationary in first difference at 1% level of significance. Conversely, the US 10-year bond rate was stationary in levels at 1% level of significance; all other variables were stationary in first difference at the same level of significance. The variables deduced from the difference between both countries' indicators, built to represent variables representable in the sticky price model were only stationary in first difference except the inflation rate differential.

In terms of short-run dynamics, two methods provided results for the short term. The first method is the impulse response function, which showed that there was no bilateral relationship between the rand/dollar and its regressors. The impact of the exchange rate on nominal variables is the only significant positive relationship, which suggests that changes in the rand/dollar are likely to influence monetary policy and prices. Another unilateral relationship exists from the exchange rate to the 10-year spread. The rand/dollar is not determined by the real sector and news variables in the short run, which is counter to the Efficient Market Hypothesis theory.

The rand/dollar was found to be significantly cointegrated with the 10-year bond rate differential relative to other variables suggested that the exchange rate is mostly determined by a financial variable in the long run. Furthermore, the results of the long-run test suggested that the exchange rate is weakly related to the monetary policy rate, output and total shares, all of which is in line with the empirical findings of similar studies. Though the exchange rate was said to be determined by financial developments in Bhundia and Gottschalk (2003), no link between the chosen news proxy and the rand/dollar was found in the long run.

Chapter Five

5. Conclusion

5.1 Introduction

The policy shift from a fixed exchange rate regime to a floating exchange rate regime is often accompanied by increased exchange rate volatility. The increased frequency and the level of volatility of the rand/dollar exchange rate debuted in 1995, when the South African Reserve Bank adopted a floating exchange rate regime. The enhanced volatility poses macroeconomics problems in the sense that an unstable currency hinders the economic health of a nation. This concern is the core of this study, as we investigate the relationship between the rand/dollar exchange rate and its determinants in order to draw inferences indicating the probable source of the volatility.

The first chapter provides the background and rationale for conducting the study, and the second chapter outlined the different exchange rate determination theories. The presentation of the theories followed a chronological outline. The theories vary from partial to general equilibrium models for exchange rate determination. The theoretical model relating the most closely to the rand/dollar exchange rate determination was found to be a monetary model, more precisely the sticky price model. The sticky price model is favoured because it makes allowances for the exchange rate to overshoot in the short run following a monetary shock. Additionally, the basic assumptions of the model are more relatable to the real world in comparison to general equilibrium models. Most importantly, the model permits the inclusion of a broader range of variables relative to some other partial equilibrium theories.

The supplementary section of the literature review encompasses empirical evidence for different economic cases, from a developed economy to the South African economy. In terms of the South African case, the rand/dollar was found to have a short-run relationship with nominal values, but the most important determinant was financial developments. These conclusions were substantiated in the study by Fedderke and Flamand (2005), which pointed out that more attention was given to good news from the USA than any good and/or bad news from South Africa.

5.2. Findings

This section provides a brief discussion of the findings in terms of short- and long term dynamics between the rand/dollar exchange rate and its determinants.

5.2.1 Short-Run Dynamics

In terms of short-term dynamics, the lesson learned from the impulse response function is that there were no strong bilateral relationships between the rand/dollar and its determinants between 1995 and 2014. The only significant relationship is between the exchange rate and nominal variables. Indeed, a depreciation of the rand/dollar exchange rate leads to an immediate and relatively substantial deviation of the interest rates and inflation rate differentials. This is somehow expected as the basic assumption suggests that changes in the exchange rate are correlated with the nominal variables in the short run. Another significant impact is that of the exchange rate on the 10-year bond rate differential. All other variables, including the total share index and news index are not determined and do not determine the rand/dollar exchange rate in the short run.

5.2.2 Long-Run Dynamics

The long-run test results suggest that the rand/dollar exchange rate is mostly related to the 10-year bond rate spread relative to all other variables. Some weak cointegration was found between monetary policy, output, total shares and the exchange rate. However, there is no clear link between the exchange rate and the news variable. Consequently, the rand/dollar is determined by nominal, real and financial variables as indicated by the theory and the findings of the various authors considered in the literature review. A lesson to take from the results is that the rand/dollar exchange rate is indeed an 'equity' currency, and is mostly affected by changes in the financial variables, more specifically the 10-year bond rate spread.

5.3 Limitations of the Study

The main limitations of the study are the presence of heteroscedasticity and the non-normality of the residuals. As previously discussed in the findings, although it is 'typical' of the exchange rate models to have such issues; we do not expect the results to constrain the provision of an adequate basis to derive structural inferences. Furthermore, the long run methods results are subjected to cautious interpretation, since the ordering of variables, the multitude of coefficients and the large confidence bands could slightly bias the results. However, this problem was overcome by using more than one method. Lastly, through using a daily frequency more precise results could be derived from the data, nevertheless most variables were not available at this frequency.

5.4 Further Research

Since the focus of this study is to look at the relationship between the exchange rate and its different determinants, a future area of research would be an examination of how to measure the magnitude of the rand/dollar exchange rate volatility. Additionally, one could compare the rand/dollar exchange rate results with a basket of emerging economies' currencies against the US dollar. The comparison would help to establish whether the rand behaves similarly or differently from these other currencies. This would aid the South African Reserve Bank and other parties involved to make informed exchange rate and monetary policy decisions.



Reference List

- Abel, A., Bernanke, S. & Croushore, D. (2011). *Macroeconomics*. Seventh Edition. New York: Pearson Education.
- Afat, D., Gómez-Puig, M. & Sosvilla-Rivero, S. (2015). The Failure of the Monetary Model of Exchange Rate Determination. Association of Economics and International Finance, *Working Papers on International Economics and Finance DEFI 15-05*.
- Aron, J. & Elbadawi, I. (1999). Reflections on the South African Rand Crisis of 1996 and Policy Consequences. *World Bank Working Papers*, WPS/99-13.
- Arratibel, O., Furceri, D., Martin, R. & Zdezienicka, A. (2011). The Effect of Nominal Exchange Rate Volatility On Real Macroeconomic Performance in the CEE Countries. *Journal of Economics systems*, 35, pp. 261- 277.
- Bachmann, A. (2012). Exchange Rate Pass-Through to Various Prices: Empirical Estimation Using Vector Error Correction Models. *University of Bern Discussion Paper*.
- Bahmani, S. (2013). Exchange Rate Volatility and Demand for Money in Less Developed Countries. *Journal of Economics and Finance*, 37, pp. 442-452.
- Barnett, W. & Kwag, C. (2005). Exchange Rate Determination From Monetary Fundamentals: An Aggregation Theoretic Approach. *University of Kansas Working Papers 200513*.
- Bhundia, A. & Gottschalk, J. (2003). Sources of Nominal Exchange Rate Fluctuations in South Africa. *International Monetary Fund Working Papers*, WP/03/252.
- Bjørnland, H. (2000). VAR Models In Macroeconomics Research. Statistics Norway, *Research Document*, 2000/14.
- Board of Governors of the Federal Reserve System. (2000). *87th Annual Report*. Washington D.C.: Board of Governors of the Federal Reserve System.
- Board of Governors of the Federal Reserve System. (2001). *88th Annual Report*. Washington D.C.: Board of Governors of the Federal Reserve System.
- Board of Governors of the Federal Reserve System. (2006). *93rd Annual Report*. Washington D.C.: Board of Governors of the Federal Reserve System.

- Board of Governors of the Federal Reserve System. (2007). *94th Annual Report*. Washington D.C.: Board of Governors of the Federal Reserve System.
- Board of Governors of the Federal Reserve System. (2008). *95th Annual Report*. Washington D.C.: Board of Governors of the Federal Reserve System.
- Board of Governors of the Federal Reserve System. (2011). *98th Annual Report*. Washington D.C.: Board of Governors of the Federal Reserve System.
- Board of Governors of the Federal Reserve System. (2012). *99th Annual Report*. Washington D.C.: Board of Governors of the Federal Reserve System.
- Board of Governors of the Federal Reserve System. (2013). *100th Annual Report*. Washington D.C.: Board of Governors of the Federal Reserve System.
- Branson, W. & Halttunen, H. (1979). Asset-Market Determination of Exchange Rates: Initial Empirical and Policy Results. *Trade and Payments Adjustment Under Flexible Exchange Rates*. Trade Policy Research Centre: Great Britain.
- Brooks, C. & Tsolacos, S. (1999). The Impact of Economic and Financial Factors on UK Property Performance. *Journal of property research*, 16(2), pp. 139-152.
- Brooks, C. (2008). *Introductory Econometrics for Finance. Second Edition*. New York: Cambridge.
- Calvo, G. & Rodriguez, C. (1977). A Model of Exchange Rate Determination Under Currency Substitution and Rational Expectations. *Journal of political economy*, 85(3), pp. 617-626.
- Chan, N. (2002). *Time series: Applications to Finance*. New Jersey: John Wiley and Sons.
- Chen, Y. & Tsang, K. (2010). A Macro-Finance Approach to Exchange Rate Determination. *University of Washington Working Paper*, WP UWEC-2009-24-R.
- Christiano, L., Eichenbaum, M. & Vigfusson, R. (2005). Assessing Structural VARs. *National Bureau of Economic Research Working Papers*, WP 12353.
- Coudert, V., Couharde, C. & Mignong, V. (2011). Exchange Rate Volatility Across Financial Crises. *Journal of Banking and Finance*, 35, pp. 3010-3018.

- De Bruyn, R., Gupta, R. & Stander, L. (2015). Testing the Monetary Model for Exchange Rate Determination in South Africa: Evidence from 101 Years of Data. *Contemporary Economics* 7(1), pp.19-32.
- Diebold, F. & Nerlove, M. (1989). The Dynamics of Exchange Rate Volatility: A Multivariate Latent Factor Arch Model. *Journal of Applied Econometrics*, 4, pp. 1- 21.
- Dornbusch, R. (1977). The Theory of Flexible Exchange Rate Regimes and Macroeconomic Policy. *The Scandinavian Journal of Economics*, 78(2), pp. 123-143.
- Duncan, A. & Liu, G. (2009). Modelling South Africa Currency Crises as Structural Change in the Volatility of the Rand. *South African Journal of Economics*, 77(3), pp. 363-379.
- Elkhafif, M. (2002). Exchange Rate Policy and Currency Substitution: The Case of Africa's Emerging Economies. *African Development Bank research papers* 71.
- Enders, W. (2014). *Applied Econometric Time Series*. Fourth Edition. New Jersey: Wiley.
- Faust, J. & Rogers, J. (2003). Monetary Policy's Role in Exchange Rate Behaviour. *Journal of Monetary Economics*, 50, pp. 1403-1424.
- Fedderke, J. & Flamand, P. (2005). Macroeconomic News "Surprises" and the Rand/ Dollar Exchange Rate. *Journal of Economics Studies: Econometrics*, 29 (3), pp. 1-15.
- Francis, B., Hasan, I. & Hunter, D. (2002). Return-Volatility Linkages in the International Equity and Currency Markets. *Bank of Finland Discussion papers* 9/2002.
- Frankel, J. (1983). Monetary and Portfolio-Balance Model of Exchange Rate Determination. *Economic Interdependence and Flexible exchange rate*. Cambridge (MA): MIT Press.
- Frankel, J. (2007). On the Rand Determinants of the South African Exchange Rate. *National Bureau of Economic Research Working Papers*, WP13050, pp. 1-19.
- Frenkel, J. (1977). Flexible Exchange Rates and Stabilisation Policy: A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence. *The Scandinavian Journal of Economics*, 78 (2), pp. 68-92.
- Gardeazabal, J. & Regúlez, M. (1992). *The Monetary Model of Exchange Rates and Cointegration: Estimation, Testing and Prediction*. Berlin: Springer-Verlag.

- Giannellis, N. & Papadopoulos, A. (2011). What Causes Exchange Rate Volatility? Evidence From Selected EMU Members and Candidates For EMU Membership Countries. *Journal of International Money and Finance*, 30, pp. 39-61.
- Giannini, C. & Mosconi, R. (1987). Predictions From Unrestricted and Restricted VAR Models. *Journal of Economics*, 46 (5/6), pp. 291-316.
- Gil, J., BenKaabia, M. & Chebbi, H. (2011). Macroeconomics and Agriculture in Tunisia. *Journal of Applied Economics*, 41(1), pp. 105-124.
- Gossel, S. & Biekpe, N. (2012). The Nominal Rand/Dollar Exchange Rate: Before and After 1995. *Journal of Studies in Economics and Finance*, (29) 2, pp. 106-117.
- Gujarati, D. & Porter, D. (2003). *Basic econometrics*. Fifth Edition. New York: Mc Graw-Hill/Irwin.
- Hooper, P. & Morton, P. (1980). Fluctuations in the Dollar: A model of nominal and real exchange rate determination. *International Finance discussion papers* 68.
- Isard, P. (1995). *Exchange Rate Economics*. Cambridge: Cambridge University Press.
- Kilian, L. (2011). Structural Vector Autoregressive. *University of Michigan Working Paper*.
- Kurihara, Y. (2012). Exchange Rate Determination And Structural Changes In Response To Monetary Policies. *Studies in Economics and Finance*, 29(3), pp. 187-196.
- Li, X. (2011). How Do Exchange Rates Co-Move? A Study on The Currencies Of Five Inflation-Targeting Countries. *Journal of Banking and Finance*, 35, pp. 418-429.
- Lütkepohl, H. & Krätzig, M. (2004). *Applied Time Series Econometrics*. United States: Cambridge University Press.
- Lütkepohl, H. (2005). *New Introduction to Multiple Time Series Analysis*. Berlin: Springer-Verlag.
- Lütkepohl, H. (2011). Vector Autoregressive Models. *European University Institute working Paper*, ECO 2011/80.
- Mills, T. (1999). *The Econometric Modelling of Financial Time Series*. Second Edition. Cambridge: Cambridge University Press.

- Mireku, K., Sarkodie, K. & Poku, K. (2013). Effects of Macroeconomic Factors on Stock Prices in Ghana: A Vector Error Correction Model Approach. *International Journal of Academic Research in Accounting, Finance and Management Sciences*, 3(2), pp. 32-43.
- Morana, C. (2009). On The Macroeconomics Causes of Exchange Rate Volatility. *International Journal of forecasting*, 25, pp. 328-350.
- Mtonga, E. (2011). *Did it matter? Monetary Policy Regime Change and Exchange Rate Dynamics in South Africa*. Available: <http://www.csae.ox.ac.uk/conferences/2011-edia/papers/354-mtonga.pdf>. [Accessed 5 July 2016].
- Mussa. M. (1977). Flexible Exchange Rate and Stabilisation Policy: Monetary and Fiscal Policy Under A Regime of Controlled Floating. *The Scandinavian Journal of Economics*, 78 (2), pp. 97-122.
- Ogun, O. (2012). Exchange Rate Determination in Developing Economies. *Journal of Modern Economy*, 3, pp. 518-522.
- Pentecost, E. (1993). *Exchange Rate Dynamics: Modern Analysis of Exchange Rate: Theory and Evidence*. United States of America: Elgar Publication.
- Rivera-Batiz, F. & Rivera-Batiz, L. (1985). *International Finance and Open Economy Macroeconomics*. New York: Macmillan Publishing Company.
- Serenis, D. & Tsounis, N. (2012). A New Approach for Measuring Volatility Of The Exchange Rate. *Journal of Procedia Economics and Finance*, 1, pp. 374-382.
- Sichei, M., Gebreselasie, T. & Akanbi, O. (2005). An Econometric Model of The Rand-US Dollar Nominal Exchange Rate. University of Pretoria: *Department of Economics Working Papers*, WP 2005-14, pp. 1-25.
- South African Reserve Bank. (1997). *Annual Economic Report*. Pretoria: South African Reserve Bank.
- South African Reserve Bank. (1998). *Annual Economic Report*. Pretoria: South African Reserve Bank.
- South African Reserve Bank. (1999). *Annual Economic Report*. Pretoria: South African Reserve Bank.

- South African Reserve Bank. (2003). *Annual Economic Report*. Pretoria: South African Reserve Bank.
- South African Reserve Bank. (2007). *Annual Economic Report*. Pretoria: South African Reserve Bank.
- South African Reserve Bank. (2008a). *Quarterly Economic Review, 2008Q1*. Pretoria: South African Reserve Bank.
- South African Reserve Bank. (2008b). *Quarterly Economic Review, 2008Q2*. Pretoria: South African Reserve Bank.
- South African Reserve Bank. (2012). *Annual Economic Report*. Pretoria: South African Reserve Bank.
- South African Reserve Bank. (2014). *Quarterly Economic Review, 2014Q2*. Pretoria: South African Reserve Bank.
- South African Reserve Bank. (2015). *Quarterly Economic Review, 2015Q1*. Pretoria: South African Reserve Bank.
- Stock, J. & Watson, W. (2001). *Vector Autoregressions*. Cambridge (MA): National Bureau of Economic Research.
- Taylor, M. (1995). The Economics of Exchange Rates. *Journal of Economic Literature*, 33(1), pp. 261-277.

