Essays on exchange rate behaviour in South Africa

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Declaration

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Abstract

The dissertation presents four essays on exchange rate behaviour in South Africa with a focus on misalignment and volatility of the real effective exchange rate (REER), and the concomitant influence of exchange rate uncertainties on both economic growth and exports. Motivating the study is the proposition in recent literature that proactive exchange rate policies centred on exchange rate disequilibria and deliberate currency undervaluation can foster economic growth through exports. Despite exchange rate behaviour receiving much attention in the literature, several questions regarding the pass-through effects to the economy remain unanswered in the South African context where the country faces the challenges of low economic growth, high unemployment and significant inequality. The major question therefore is whether exchange rate policy can be used in South Africa to promote exports, thus aiding economic growth and employment creation. To answer this question, I model exchange rate misalignment and volatility, and then assess the influence of both factors on growth and exports with an emphasis on the possible asymmetries in the reaction to undervaluation and overvaluation episodes. The results are presented in four essays.

In this context, the first essay applies cointegration techniques in the behavioural equilibrium exchange rate (BEER) framework of Clark and MacDonald (1998) to estimate the equilibrium value of the rand consistent with economic fundamentals, and interpret the deviation of the observed exchange rate from this level as exchange rate misalignment. A Markov regime switching method is then applied to quantify whether the exchange rate's departure from the equilibrium level is meaningful enough to be considered as either over- or undervalued. The results indicate that a long-run equilibrium relationship exists between the rand's REER and economic variables that include the terms of trade, external openness, external capital flows and government expenditure. Frequent deviations of the observed exchange rate from the estimated equilibrium level are found over the period studied (1985-2014) and the Markov regime-switching model correctly captures the exchange rate misalignment as distinct episodes of exchange rate overvaluation and undervaluation. It is important to note that the observed misalignments have been mainly in response to economic shocks emanating from either the South African economy or global factors and not in response to deliberate policy action.

In the second essay, univariate symmetric and asymmetric generalised autoregressive conditional heteroscedasticity (GARCH) approaches are used to model the volatility of the South African rand's REER. The objective is to explore the relevance and compare the performance of the GARCH family of models in terms of their ability to capture the stylised facts of the rand's volatility and thus identify the best model to apply for volatility modelling and forecasting. The findings from the essay show that exchange rate volatility in South Africa is quite persistent and exhibits volatility clustering and asymmetric effects. In terms of sample-fit, the results confirm that the GJR-GARCH (1,1) with the normal error distribution is the best fitting model for the rand's REER volatility, when compared to the ARCH, GARCH (1,1) and EGARCH (1,1) models with in-mean and different error distribution

assumptions. The GJR-GARCH (1,1) model is able to accurately capture the significant increases in exchange rate volatility experienced in South Africa over the sample period, with such episodes of high volatility linked to the historical exchange rate depreciation experiences (e.g. at the height of the political crisis in 1985, the emerging market crisis of 1997-1998, speculative attacks on the rand in 2001 and lastly the global financial crisis of 2007-2008).

Asymmetric autoregressive distributed lag (ARDL) cointegration methods are used in the third essay to explore the effects of exchange rate misalignment on economic performance. Specifically, I investigate the response of economic performance to exchange rate misalignment depending on the direction and size of misalignment such that the reaction would be contingent on whether the exchange rate is undervalued or overvalued, and if the magnitude of the misalignment (small or large) is important in explaining the influence on the economy. Given the fact that both exchange rate misalignment and volatility represent uncertainty, the essay also seeks to ascertain whether a combination of both uncertainty indicators could be important in explaining the exchange rate's influence on economic activity. Although not robust, the results confirm asymmetry in the reaction of economic performance in South Africa to exchange rate misalignment, with exchange rate undervaluation of approximately 10% being positively correlated with economic performance. Although not statistically significant, the results indicate that exchange rate overvaluation has a negative influence on economic performance in South Africa. Finally, the essay concludes that exchange rate volatility, as specified through a GJR-GARCH (1,1) model, does not have a significant influence on real GDP.

The last essay empirically assesses the reaction of South Africa's exports to exchange rate misalignment occurrences and volatility with the major focus being possible asymmetries in such a relationship. This study brings in a new dimension to the literature by making a comparison as to whether it is only exchange rate misalignment or volatility, or a combination of both, that influences South African exports at both aggregate and sectoral levels. At the aggregate level, the findings confirm asymmetry as exports appear to benefit less from exchange rate undervaluation than they suffer from an overvalued exchange rate. The same observation is true for manufactured exports, while the results confirm no meaningful relationship between exchange rate misalignment and agricultural and mining exports. On volatility, it is found that this variable on its own does not have an influence on exports. When considered together with misalignment (overvaluation and undervaluation), volatility exerts a negative and statistically significant influence on both gross and manufactured exports. Regarding the size of misalignment (for both overvaluation and undervaluation), based on the sample data, the study fails to confirm evidence of hysteresis in the reaction of exports to exchange rate misalignment for both aggregate and manufactured exports. This result is probably a confirmation of the weak influence of exchange rate misalignment on exports in South Africa.

In summary, the thesis contributes to the literature on modelling exchange rate misalignment and volatility in South Africa. The main contribution of the study is through testing for asymmetries in the reaction of economic performance and export performance to exchange rate developments in the country. The results from the study provide credence to the view that maintaining the exchange rate at an appropriate competitive level is desirable as a measure to boost manufactured exports and growth, although such a policy should be secondary to labour productivity, and a good supportive infrastructure that allows manufacturers to produce at full capacity, together with macroeconomic stability. From a policy perspective, efforts to avoid exchange rate overvaluation and smooth out excessive currency volatility are desirable as a measure to support South Africa's economic performance. In episodes of exchange rate appreciation and concomitant overvaluation, the Reserve Bank could use such opportunities to intervene in the foreign exchange market as a measure to boost foreign exchange reserves. Further research in this area could focus on the application of different methods to estimate the equilibrium exchange rate (e.g. FEER, NATREX) or the influence of exchange rate misalignment on other economic variables such as investment, imports, the balance of payments or employment.

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List of Acronyms

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
APARCH	Asymmetric Power ARCH
ARCH	Auto Regressive Conditional Heteroscedasticity
ARDL	Autoregressive Distributed Lag
AUD	Australian Dollar
BEER	Behavioural Equilibrium Exchange Rate
BIS	Bank for International Settlements
BRICS	Brazil, Russia, India, China and South Africa
CAD	Canadian Dollar
CGER	Consultative Group on Exchange Rate Issues
CHF	Swiss franc
CUSUM	Cumulative Sum of Recursive Residuals
CUSUMQ	Cumulative Sum of Squared Recursive Residuals
DEM	Deutsche mark
DOLS	Dynamic Ordinary Least Squares
ECM	Error Correction Model
EGARCH	Exponential GARCH
EMU	European Monetary Union
ERPT	Exchange Rate Pass-Through
EUR	European Single Currency
FEER	Fundamental Equilibrium Exchange Rate
FIAGARCH	Fractionally Integrated APARCH
FIEGARCH	Fractionally Integrated EGARCH
FIGARCH	Fractionally Integrated GARCH
FMOLS	Fully Modified Ordinary Least Squares
FPE	Final Prediction Error
GARCH	Generalised Auto-Regressive Conditional Heteroscedasticity
GARCH-M	GARCH-in-Mean
GBP	Great British Pound
GDP	Gross Domestic Product
GJR-GARCH	Glosten, Jagannathan and Runkle GARCH
HP	Rodrick-Prescott
HQ	Hannan-Quinn Information Criterion
HYGARCH	Hyperbolic GARCH
IGARCH	Integrated GARCH

IMF	International Monetary Fund
JPY	Japanese Yen
MAE	Absolute Mean Error
MAPE	Mean Absolute Percentage Error
MASD	Moving Average Standard Deviation
ME	Mean Error
MENA	Middle East and North Africa
MIS	Exchange Rate Misalignment
MSE	Mean Squared Error
MS GARCH	Markov Switching GARCH
MSM	Markov Regime Switching
NARDL	Nonlinear Autoregressive Distributed Lag
NATREX	Natural Real Exchange Rate
NEER	Nominal Effective Exchange Rate
OLS	Ordinary Least Squares
PARCH	Power ARCH
PPP	Purchasing Power Parity
PSTR	Panel Smooth Transition Regression
REER	Real Effective Exchange Rate
RMSE	Root Mean Square Error
SARB	South African Reserve Bank
SIC	Schwartz Information Criterion
TAR	Threshold Autoregressive
TGARCH	Threshold GARCH
USD	United States Dollar
VECM	Vector Error Correction Model

CHAPTER 1:
INTRODUCTION

1.1 INTRODUCTION

The exchange rate arguably remains one of the most closely monitored economic indicators by policymakers, financial market participants and industries involved in international trade. Since it essentially reflects a country's competitiveness in international markets, the exchange rate has a major influence on economic activity mainly through the external sector. Exchange rate misalignment – where the exchange rate deviates from its long-run equilibrium level resulting in either an over- or undervalued currency – has generated wide interest in recent years due to increased levels of external openness that support global trade and capital flows. There is empirical evidence to suggest that keeping the exchange rate close to its long-run equilibrium level is a necessary pre-condition for growth, with countries that avoid currency overvaluation linked to export-led economic growth and export diversification (Elbadawi, Kaltani & Soto, 2012). Notwithstanding the vast literature that exists on exchange rate management, research in this area still generates interest given the fact that exchange rates are not only comparative price indicators, but also designate the relative competitiveness of a country against the rest of the world (Dufrenot & Yehoue, 2005). The evolving nature of the key drivers of exchange rates and the subsequent practical implications for macroeconomic management accordingly necessitate continuous research in the area.

It has also been argued that some countries (especially Asian nations) have pursued mercantilist policies whereby undervalued exchange rates are used to support export-led economic growth. From a global perspective, such exchange rate misalignments have contributed to the global macroeconomic imbalances and the ongoing political debates, with some major developed nations experiencing sustained deficits on their current accounts (particularly the United States and Eurozone) and other countries (especially emerging markets such as China) having huge surpluses (see Holtemöller & Mallick, 2013; López-Villavicencio, Mazier & Saadaoui, 2012). Although an undervalued exchange rate can support economic growth, an overvalued currency has the potential to undermine economic performance through poor growth, an unsustainable current account deficit and a potential currency crisis (Rodrik, 2008a; Naseem & Hamizah, 2013). Against this backdrop, it is important to note that a highly undervalued exchange rate is undesirable since it can lead to higher inflation and macroeconomic instability (Berg & Miao, 2009) such that there could be a threshold level beyond which undervaluation becomes undesirable.

In the current context of global imbalances and the role of countries such as China (who is now South Africa's largest trading partner), exploring the issue of currency misalignment is important for South Africa due to the importance of trade as a potential driver of economic growth and employment generation. In addition to misalignment, exchange rate volatility, which is defined as the short-term fluctuation in the real effective exchange rate (REER) as measured by its conditional variance, may constrain international trade through introducing uncertainties and hedging costs for the external sector. This will have a negative impact on economic growth and job creation compared to an environment where volatility is non-existent or negligible. Vieira, Holland, da Silva & Bottecchia (2013) note that it is not only the level of the real exchange rate and its misalignment that are important for economic growth, but also its volatility since exchange rate variations have an influence on trade and investment. This therefore reinforces the need to accurately measure the extent of real exchange rate volatility and to further assess its impact on the overall macroeconomy. Notwithstanding the progress made in recent years regarding exchange rate modelling, many issues around currency misalignment, volatility, trend movements and spillover effects remain unresolved.

1.2 BACKGROUND: SOUTH AFRICA

As a small open economy with a floating exchange rate and an outward looking trade policy (see Takaendesa, Tsheole & Aziakpono, 2006; Sekantsi, 2011), exchange rate movements have the potential to influence economic activity in South Africa. Edwards and Garlick (2008) confirm the central role played by the value of the rand in public discussions on trade and trade policy in the country, with labour organisations mainly calling for a policy that facilitates exchange rate depreciation. The current economic climate in South Africa presents an interesting case study as the country is facing several challenges, with slow economic growth and high unemployment amongst the most challenging issues confronting policymakers. The South African National Development Plan 2030 (Economic Development Department, 2011) – essentially a medium- to long-term plan aimed at increasing overall South African prosperity – identifies raising exports in areas such as mining, mid-skill manufacturing, agriculture and agro-processing as one of the ways to increase employment and boost economic growth in the country. Given the renewed interest in the relationship between exchange rate movements and economic performance, studying the influence of the exchange rate of the rand on the country's economic activity is worthwhile as the subject has received limited attention in the South African context. Moreover, the South African rand has been observed to exhibit cyclical appreciation and depreciation trends that coincide with high levels of volatility, and such patterns increase the likelihood of exchange rate misalignment which might feed into long-term economic performance. Also noteworthy along this line of argument is the fact that South Africa is facing a declining manufacturing sector (measured as a percentage of gross domestic product (GDP)) and a chronic current account deficit, the latter of which is normally cited as one of the most pertinent structural weaknesses in the country's economy (IMF, 2014). The New Growth Path Framework (2011), which provided government's blueprint for economic growth and job creation, calls for a more competitive exchange rate that should support government's initiatives, indicating that policymakers have a vested interest in seeing the exchange rate at a level that would support economic growth.

The South African rand, under the South African Reserve Bank's (SARB) current inflation targeting monetary policy framework, is a free-floating currency with its value determined by market forces.

Such a foreign exchange policy has rendered the rand to be a volatile currency given the country's developed financial markets and high levels of participation by foreigners in the local markets. South Africa's REER has therefore undergone considerable variations over the past few decades covering cycles of appreciation and subsequent declines. Saayman (2007) notes that the rand's appreciation in 2002 raised concerns about the competitiveness of South African exports from the mining houses and labour unions. This raised calls for and exerted pressure on the SARB to weaken the currency in an effort to boost exports and employment creation. The Manufacturing Circle (a group of South Africa's leading medium- to large-scale manufacturing companies from a wide range of industries) cited the appreciation of the rand (trend) and its volatility as one of the principal drivers of the country's observed de-industrialisation process, accordingly arguing that a competitive exchange rate would boost the productive capacity of the export sector (Manufacturing Bulletin, December 2010).

It is against this background that we need to constantly address questions such as the extent to which the rand's REER has diverted from its long-run equilibrium level, the sign of the deviations and its speed of adjustment, the forces driving such exchange rate movements, the volatility of the exchange rate, and the possible impact of exchange rate misalignment and volatility on trade (imports, exports and the balance of payments) and economic performance. As Rodrik (2008a) points out that an undervalued exchange rate makes a positive contribution to economic growth, one would be interested in determining if there is scope for South African policymakers to effectively use exchange rate policy to stimulate economic growth given the country's challenges of low economic growth, and high poverty and inequality levels. A rigorous and appropriate measurement of exchange rate misalignment allows policymakers to suitably assess and monitor real exchange rate behaviour and the consequences of either over- or undervaluation. An awareness of the existence and extent of exchange rate deviations from their long-run equilibrium levels would therefore indicate the need for appropriate corrective policy actions in an effort to either support economic growth or deal with the adverse effects of such misalignment (Holtemöller & Mallick, 2013). From a volatility perspective, with the rand notably one of the most volatile currencies when compared to its emerging market peers (see Aye, Gupta, Moyo & Pillay, 2015; Hassan, 2015), such exchange rate behaviour raises numerous challenges for policymakers, investors and companies engaging in international trade. It is therefore crucial to accurately model the rand's volatility so as to correctly assess the impact of such volatility on macroeconomic factors.

1.3 RESEARCH OBJECTIVES

Given the context of South Africa's economic challenges and the possible influence of the exchange rate on economic outcomes, the study addresses the following four questions, each of which culminates in a stand-alone essay:

A. To what extent is the REER of the South African rand misaligned; i.e. is the exchange rate overvalued, undervalued or close to its long-run equilibrium level? To this end, it is imperative that the long-term equilibrium REER is estimated. The aim of the first essay therefore is to determine the extent to which the rand's REER is misaligned from its equilibrium level. This is achieved through using co-integration techniques in the behavioural equilibrium exchange rate (BEER) framework of Clark and MacDonald (1998) to estimate the equilibrium value of the rand consistent with economic fundamentals, and to interpret the deviation of the observed exchange rate from this level as REER misalignment. In a similar fashion to Terra and Valladares (2010), a Markov regime switching (MSM) method is then applied to quantify whether the exchange rate's departure from the equilibrium level is meaningful enough to be considered as either over- or undervalued.

B. How volatile is the REER and which volatility modelling method best captures the dynamics of the rand exchange rate? Given the well observed influence of exchange rate volatility on macroeconomic factors (e.g. trade, investment, economic growth and employment), the second essay seeks to ascertain which modelling approach or technique correctly captures the volatility characteristics of the South African rand. In this regard, the modelling abilities of symmetric and asymmetric generalised autoregressive conditional heteroscedasticity (GARCH) models are explored in order to identify the most appropriate method to be applied in REER volatility modelling.

C. What are the implications of exchange rate misalignment on economic performance in South Africa? Based on the misalignment behaviour observed in the first essay, the third essay seeks to answer the question of whether there is any observable relationship between economic performance and exchange rate misalignment in South Africa. More specifically, I investigate the response of economic performance to exchange rate misalignment depending on the direction and size of misalignment (i.e. whether or not the impact is symmetric or asymmetric), and if the magnitude or size of the misalignment (small or large) is important in explaining the impact on economic growth. This is important since the impact of rand overvaluation is likely to be different from that of undervaluation, with the size of such misalignment being another possible influential factor. The analysis is extended further in the essay to ascertain whether volatility (represented by the model identified in essay 2) – as another form of exchange rate uncertainty – has an influence on growth when considered together with misalignment.

D. Is there asymmetry and hysteresis in the response of exports to exchange rate misalignment occurrences? Building on the first two essays, the fourth essay applies nonlinear cointegration methods to ascertain the likelihood of asymmetries in the reaction of South Africa's exports to over- and undervaluation episodes. The major objectives are to assess whether exports benefit from an undervalued currency and whether an overvalued exchange rate undermines exports. Furthermore, I seek to find out if there are any thresholds in the level of misalignment that influence the reaction of exporters (large versus small changes) to exchange rate movements. In addition to total exports, the essay considers the response of manufacturing, mining and agricultural exports to exchange rate misalignment occurrences. These sectors are considered because of their key influence as possible major drivers of employment creation and economic growth in South Africa. Finally, the essay assesses the possible combination of exchange rate misalignment and volatility as potential drivers of export behaviour in South Africa, given the likelihood that the positive effects of undervaluation could be overshadowed by the negative effects of volatility.

1.4 RESEARCH CONTRIBUTION OF THE STUDY

The thesis seeks to make a contribution to the literature in the following aspects:

A. Firstly, the study presents the latest attempt at modelling the equilibrium REER of the rand and the extent of exchange rate misalignment in South Africa – a topic that has generated renewed interest in recent years whilst not clearly defined in the literature from the outset. Exchange rate misalignment has the potential to influence economic activity, hence it is important for policymakers to understand how the exchange rate is moving relative to its equilibrium level. With such information, policymakers such as the central bank could take appropriate policy action that is aimed at influencing economic activity. The subject of exogeneity in the equilibrium exchange rate model is also addressed in the study since most studies in the South African literature have largely ignored the matter. Paying attention to this issue ensures that the correct exchange rate model is applied in the analysis.

B. Regarding real exchange rate volatility, a contribution is made in terms of an initiative to identify the most appropriate approach for modelling the rand's volatility. Most studies specific to South Africa that focus on the effects of exchange rate volatility choose and apply different measures of volatility, with limited attempts in the literature to compare the modelling and forecasting power of the different specifications. The study therefore seeks to extend the literature by identifying a model that produces a better exchange rate volatility measure of the rand (REER) such that it could be applied in empirical studies, volatility forecasting and risk management.

C. Through an application of nonlinear cointegration methods, the thesis explores the possibility of asymmetries (in sign and size) in the reaction of economic growth and exports to exchange rate overvaluation compared to undervaluation episodes. Given the proposition in recent literature (e.g. Rodrik, 2008a) that proactive exchange rate policy that applies exchange rate disequilibria and deliberate currency undervaluation can foster economic growth through higher exports, and the success of such policies in some Asian countries, the key policy question becomes whether South Africa can use the exchange rate to drive exports and economic performance. Affirmation of a positive impact of undervaluation on exports could render exchange rate management a possible policy instrument for growth promotion as it could be used as an alternative policy measure to address the challenges of poor economic growth rates, high unemployment and poverty levels. Equally important, however, is the question of whether or not there is a threshold of undervaluation that stimulates growth, after which growth may be hindered. The thesis thus provides evidence on the links between exchange rate misalignment, exports and economic growth in South Africa with an emphasis on the possible asymmetries in such relationships.

D. Lastly, as a further contribution, the study considers the possibility that a combination of exchange rate misalignment and volatility could be important as indicators of the influence of exchange rate uncertainty on exports and economic performance in South Africa. Although an undervalued exchange rate could contribute positively to export performance and economic growth, exchange rate risk, as represented by the volatility of the exchange rate, has the potential to offset or even dominate the positive effects of undervaluation. In the thesis, the net effects of both exchange rate misalignment and volatility on exports and growth are explored. Only a limited number of studies have followed this approach, while the author has no knowledge of any study specifically focusing on the asymmetric and nonlinear reaction of growth and exports to exchange rate misalignment and volatility in South Africa.

1.5 STRUCTURE OF THE THESIS

Following this introductory chapter, the rest of the thesis is organised as four empirical essays presented in different chapters as follows:

The second chapter (first essay) applies BEER methods and a Markov regime switching model to show that the rand's REER constantly deviates from its estimated equilibrium level culminating in episodes of exchange rate over- and undervaluation. The aim of this essay therefore is to determine the extent to which the rand's REER is misaligned to its equilibrium level over time. Results from this essay form the foundation for the analysis in the rest of the thesis that focus on the effects of exchange rate misalignment on other macroeconomic variables.

Chapter 3 (second essay) is devoted to modelling the rand's REER volatility by means of various GARCH models and under different distributional assumptions. The objective of the essay is to ascertain which modelling approach or technique correctly captures the volatility characteristics of the South African rand such that it could be applied in empirical analysis or volatility forecasting.

The third essay, presented in Chapter 4, applies the Autoregressive Distributed Lag (ARDL) cointegration method to provide evidence that economic performance in South Africa responds differently to exchange rate over- and undervaluation. Evidence of the impact of exchange rate volatility on economic performance is also presented in this chapter. The key objective addressed in this essay is whether economic growth responds to exchange rate misalignment, whether such response is asymmetric, and whether exchange rate volatility dominates the effects of exchange rate misalignment.

By applying a nonlinear autoregressive distributed lag (NARDL) model, the last essay (Chapter 5) explores the likelihood of asymmetry and nonlinearities in the reaction of aggregate and sectoral exports to overvaluation and undervaluation episodes in South Africa. I also consider in this part of the thesis the possibility that a combination of exchange rate misalignment and volatility could influence the performance of exports. The major objective is to evaluate whether exports are supported by an undervalued currency compared to an overvalued exchange rate, and whether exchange rate volatility matters when considering such a relationship.

Chapter 6 provides a summary of the findings of all four essays and concludes the thesis.

CHAPTER 2:
THE BEHAVIOUR OF THE REAL EFFECTIVE EXCHANGE RATE OF SOUTH AFRICA: IS THERE A MISALIGNMENT?[1]

2.1 INTRODUCTION

Debate about the equilibrium level of the South African rand and the factors driving the currency is ongoing, with a concomitant lack of consensus on the most appropriate level of the exchange rate in line with the country's economic fundamentals. Given that the country is an open emerging market closely linked with global markets, it renders the economy highly vulnerable to international trade and capital flow patterns, and external shocks. Within this context, the aim of this essay is to determine the extent to which the rand's REER is misaligned with its equilibrium level. This is achieved via the following manner: i) use co-integration techniques in the BEER framework of Clark and MacDonald (1998) to estimate the equilibrium value of the rand consistent with economic fundamentals; and ii) to interpret the deviation of the observed exchange rate from this equilibrium level as REER misalignment. In a similar fashion to Terra and Valladares (2010), an MSM is then applied to quantify whether the exchange rate's departure from the equilibrium level is meaningful enough to be considered as either over- or undervalued. As opposed to previous studies that mainly answer the question of whether the exchange rate is under- or overvalued, this study considers the relative probability of under- against overvaluation and the likelihood of moving from one state to another in what is known as 'regime switching'.

The rest of the chapter addresses the following issues: Section 2.2 provides a historical background of the rand's movements together with a selection of South Africa's economic indicators. Section 2.3 presents the theoretical foundation of equilibrium REER modelling, and a review of relevant previous studies on exchange rate modelling. The empirical method applied is presented in Section 2.4, with the results presented in Section 2.5. The conclusion and policy implications are provided in Section 2.6.

2.2 EXCHANGE RATE PERFORMANCE IN SOUTH AFRICA

South Africa's exchange rate policy has evolved over the past 30 years, moving broadly from a managed float to a fully floating exchange rate regime. Prior to 1970, the exchange rate of the South African rand was pegged to the British pound (Reinhart & Rogoff, 2002). From the early 1970s to the year 2000, the country applied a managed float exchange rate policy (including a dual exchange rate system) where the central bank intervened in the market in order to limit excessive exchange rate fluctuations and to influence the direction of the rand within a broader eclectic monetary policy

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[1] Two articles based on this essay entitled "*The behaviour of the real effective exchange rate of South Africa, is there a misalignment?*" have been published by Economic Research Southern Africa as Working Paper no. 644 (2016) and Research Brief no. 120 (2017).

framework. The implementation of an inflation-targeting monetary policy framework in 2001 introduced the current regime of a freely floating exchange rate where market forces directly determine the movement of the currency.

The evolution of the exchange rate (both nominal and real) is represented below in Figure 2.1, which indicates that the nominal effective exchange rate (NEER) has consistently depreciated since 1985. The REER, on the other hand, has undergone periods of cyclical movement with appreciation periods followed by subsequent weakening in the currency, with movements in the exchange rate thus also indicating the presence of volatility. Between 1985 and 2014, about four REER currency episodes[2] can be identified: two appreciation and two depreciation periods (Figure 2.1).

In the early 1980s up until the pre-1994 democratic elections, political tensions in South Africa, economic sanctions and capital controls had a major influence on the country's exchange rate movements. This period was marred by a consistent depreciation in the nominal exchange rate, capital outflows, low GDP growth and a positive balance on the current account (Table 2.1 below). Although the 1985 debt crisis (where foreign banks recalled their loans to South Africa with no new credit extended) caused a sharp decline in the exchange rate, the REER appreciated modestly between 1986 and 1993 with the index rising from around 81 in 1986 to 111.04 at the end of 1992, mainly on the back of a decline in South Africa's inflation rate (episode 1). The period between 1993 and 2001 saw the REER index decline from above 110 to reach 71 at the end of 2001, with the currency depreciating steeply between 1998 and 2001 (episode 2). This took place against the backdrop of improved macroeconomic performance and a re-integration of the country into the global economy following the successful transition to democracy in 1994. Factors that include possible contagion from the 1997-1998 Asian financial crisis, low global commodity prices and speculative attacks on the currency caused a severe depreciation in the exchange value of the rand. The extent of currency depreciation over this period raised questions as to whether this was a temporal deviation of the rand from its equilibrium level (MacDonald & Ricci, 2004).

[2] For the purposes of this study, an episode is defined as a consistent trend movement of the exchange rate in either direction (consistent REER appreciation or depreciation) which should theoretically increase the probability of misalignment. Appreciation episodes have the potential to cause exchange rate overvaluation whilst depreciation episodes are more likely to cause the exchange rate to be undervalued.

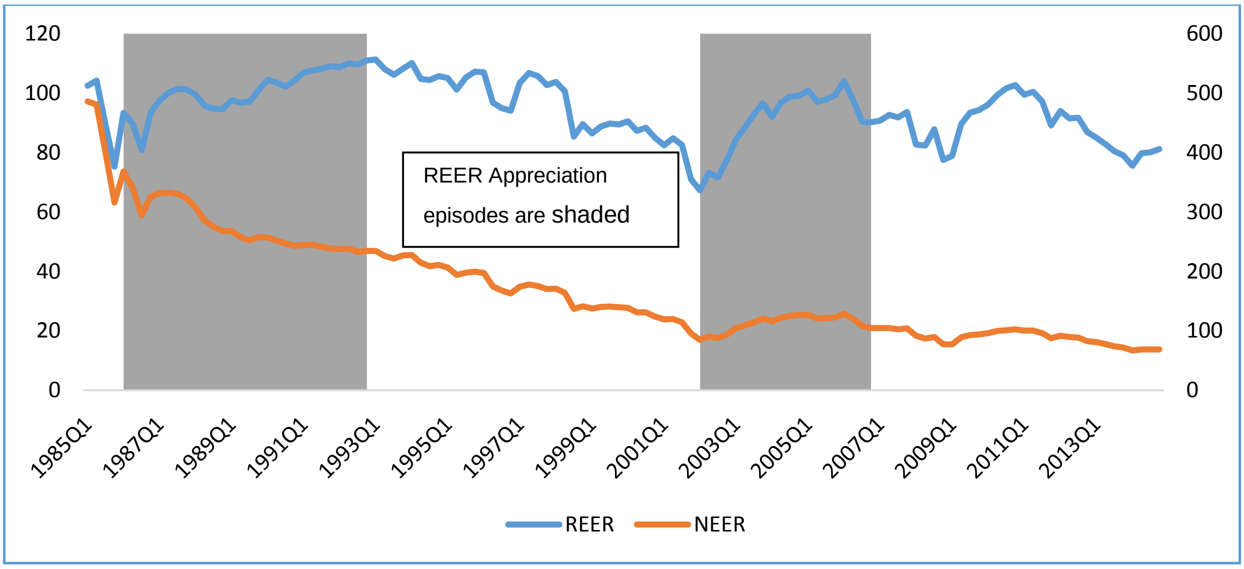

Figure 2.1: Rand REER and NEER historical performance

Source: SARB

The currency recovered sharply from the end of 2001, resulting in an appreciation episode from 2002 until 2006 where the REER strengthened by around 34%. This episode was driven by an appreciation in the NEER and declines in the inflation rate. The extent and speed of the recovery in the rand suggest that the currency might have been highly undervalued in 2001, thus necessitating a correction. As noted by Saayman (2007), the strengthening currency in 2002 raised debate about the appropriate level of the exchange rate and competitiveness of South African exports with mining companies, the manufacturing sector and labour movements being the most vocal about the negative impact of the stronger currency.

The global financial crisis in 2007 and the subsequent collapse in global trade flows, the decline in economic performance and the increase in global financial market volatility (especially risk perception towards emerging markets such as South Africa) had a major impact on the currency. The REER declined from 90.78 at the beginning of 2007 to 77.55 in 2008Q4 before regaining about 30% to recover and reach a level of 106.76 in 2010Q2. The REER depreciated gradually from this 2010 level to end 2014 at 81.20. Such developments, especially the extent of the weakness in the nominal exchange rate, again raised apprehension about whether such movements reflect South Africa's economic fundamentals and whether the currency was correctly priced, or whether this signified a misalignment in the exchange rate. It is also worth noting that the country faces a current account deficit that has been steadily increasing over a number of years, a decline in the manufacturing sector's contribution to GDP, an improving terms of trade position and an increase in imports as a percentage of GDP compared to exports (Table 2.1). All these factors are likely to have a link to REER developments over time.

Table 2.1: Historical data of selected economic indicators

Averages of quarterly data				
	1985-1992	**1993-2001**	**2002-2006**	**2007-2014**
REER (Index: 2010=100)	99.77	97.12	90.87	89.10
NEER (Index: 2010=100)	294.19	170.00	112.60	88.52
USD/ZAR	2.46	5.17	7.53	8.38
GDP growth	0.36	3.02	4.63	2.30
Terms of trade (including gold)	72.51	71.50	79.05	96.68
Exports to GDP	26.08	24.40	27.96	30.71
Imports to GDP	19.68	22.12	27.14	31.44
Gold price (USD)	379.95	330.00	426.49	1209.96
RSA 10 yr. bond yield	16.21	14.48	9.33	8.37
Government debt to GDP	31.41	45.43	34.66	35.01
Manufacturing to GDP	16.79	15.95	15.50	14.50
Current account Deficit to GDP	2.72	-0.45	-2.05	-4.18
CPI	15.08	7.19	5.20	6.70

Data source: SARB

2.3 THEORY AND RELATED LITERATURE

2.3.1 Theoretical foundations

Various theoretical approaches and empirical models have been used in the literature to estimate the equilibrium real exchange rate and the extent of misalignment, which is defined as the gap between the estimated and the observed REERs. In a comprehensive review of the different methodologies that have been applied to REER estimation, Driver and Westaway (2004) note that different theoretical measures of the REER are conceptually divergent and can thus offer different results of misalignment given the different possible definitions of equilibrium and the time horizon applicable. The Purchasing Power Parity (PPP) theory represents the oldest and most widely accepted starting point for equilibrium exchange rate estimation and relies on relative prices as the key driver of exchange rates (Aflouk, Jeong, Mazier & Saadiou, 2010). The foundation of the PPP theory is the law of one price, which states that the prices of similar tradable goods will converge across borders (Balcilar, Gupta & Jooste, 2014) and a country's currency should purchase the same basket of goods and services in local and foreign markets.

Empirical evidence on the validity of the PPP theory suggests that the approach is inadequate to explain the equilibrium exchange rate since real exchange rates have been observed to depart for long periods from their PPP levels; that is, exchange rates fail to converge to a constant mean (Saayman, 2007; Driver & Westaway, 2004; MacDonald, 2000; Siregar, 2011). Theoretically, the shortcoming of the PPP as a determinant of equilibrium exchange rates comes from its failure to capture the role of capital flows and other fundamental determinants of real exchange rates (Hossfeld, 2010). Closely linked to the PPP theory is the monetary approach to the equilibrium exchange rate which postulates that exchange rates are driven by the relative excess money supply across countries (MacDonald, 2000). Driver and Westaway (2004) note that this model seeks to improve on the PPP's ability to explain exchange rate behaviour by acknowledging the influence of asset markets, but conclude nonetheless that such methodology is only suitable for explaining short-run movements in nominal exchange rates. Limitations of the PPP theory motivated the development of more recent methodologies for equilibrium exchange rate determination.

The International Monetary Fund's (IMF) Consultative Group on Exchange Rate Issues (CGER) identifies three approaches to equilibrium exchange rate determination, which are backed by different theoretical underpinnings: the *Macroeconomic Balance Approach*, the *Equilibrium Real Exchange Rate Approach* and the *External Sustainability Approach* (Bussière, Ca'Zorzi, Chudik & Dieppe, 2010; Ajevskis, Rimgailaite, Rutkaste & Tkačevs, 2010; IMF, 2006). The macroeconomic balance and external sustainability methods are closely related as they are based on Williamson's (1993, 1994) concept of fundamental equilibrium exchange rates (FEERs) (Bussière *et al.*, 2010). These approaches emphasise the balance on the current account such that the equilibrium real exchange rate is the one that ensures that the current account adjusts back to its norm over time with the only difference between the two methods being how to estimate the long-run current account balance. Both methods therefore seek to explain the equilibrium exchange rate as the one that is consistent with attaining macroeconomic equilibrium for a given country. Aflouk *et al.* (2010: 33) define the FEER as the exchange rate that prevails when the economy simultaneously reaches internal equilibrium (full utilisation of productive capacity) and external equilibrium (sustainable current account).

The equilibrium real exchange rate approach on the other hand, advocated by Clark and Macdonald (1988), is associated with the concept of a behavioural equilibrium real exchange rate (BEER) where the REER is a function of a given set of the country's economic fundamentals without any specific reference to the attainment of internal or external equilibrium (Ajevskis *et al.*, 2010). MacDonald (2000) stresses that BEER methodology explicitly acknowledges the role of real factors as the key determinants of equilibrium real exchange rates. The IMF (2006) notes that the three approaches are complementary such that a combination of them, together with country specific economic variables, can help infer good judgments about a country's real exchange rate and current account movements over the medium term.

Broadly speaking, the estimation of equilibrium exchange rates has therefore taken theoretical approaches based on either the FEER methodology (macroeconomic balance or external sustainability) or the BEER approach (equilibrium exchange rate) with several variations of both approaches identifiable in the literature (Aflouk *et al.*, 2010). López-Villavicencio *et al.* (2012) state that despite the conceptual differences, FEER and BEER methodologies complement one another rather than being substitutes. The BEER model is the preferred method for the study for its practical approach to equilibrium exchange rate estimation and ease of application to developing countries (Gan, Ward, Ting & Cohen, 2013). A major shortcoming of the FEER approach is that the equilibrium level of the exchange rate is highly influenced by the normative assumptions around the internal (full employment and low employment condition) and external balance (sustainable current account) positions (Ajevskis *et al.*, 2010). The BEER method, on the other hand, is statistically significant and free of normative judgments.

2.3.2 Review of related literature

Empirical literature on exchange rate modelling and the extent of REER misalignment across countries is abundant. Given the wide-ranging nature of the literature, the brief review presented is not exhaustive and focuses mainly on the studies that are specific to South Africa (summarised in Table 2.2 below). In the literature, Aron, Elbadawi and Kahn (1997) are credited with pioneering the modelling of the rand's long-run equilibrium real exchange rate. Using quarterly data from 1970 to 1995, the authors employ cointegration and error correction methodology to model the long- and short-run determinants of the real exchange rate within the macroeconomic balance approach. Their study concludes that the exchange rate is a function of variables such as trade policy, terms of trade, capital flows, technology, official reserves and government expenditure. Aron *et al.* (1997) find that the real exchange rate evolves and fluctuates over time to reflect changes in several economic fundamentals and other shocks to the economic system.

MacDonald and Ricci (2004) use the BEER method within a vector error correction model (VECM) framework to estimate a long-run cointegrating relationship between the REER and various economic variables over the period from 1970 to 2002. They find that long-run real exchange rate movements in South Africa could be explained by commodity price movements, productivity,[3] real interest rate differentials against trading partners, the fiscal balance, the net foreign assets position and a measure of trade openness. Several manifestations of exchange rate misalignment were identified in the study, confirming that the rand was undervalued by more than 25% in early 2002 following the sharp depreciation in the nominal exchange rate in 2001. MacDonald and Ricci (2004) state that deviations from the equilibrium exchange rate would normally be eliminated within a short period of time if there are no other shocks to the system (28% speed of adjustment in the cointegrating equation).

[3] MacDonald and Ricci (2004) measure productivity as the log of real GDP relative to South Africa's trading partners.

Du Plessis (2005) raises the important issue of endogeneity in econometric modelling and questions the validity of MacDonald and Ricci's (2004) results since the exchange rate was weakly exogenous in their preferred model. Besides the existence of an equilibrium relationship between the real exchange rate and the economic fundamentals, Du Plessis (2005) states that the other condition necessary for an equilibrium exchange rate model is that the exchange rate should be endogenous in the model such that disequilibria must have a feedback effect on the real exchange rate. With MacDonald and Ricci's model violating the necessary condition of endogeneity, Du Plessis (2005) concludes that their model does not qualify as an equilibrium exchange rate model. In response to Du Plessis (2005), MacDonald and Ricci (2005) extend their data by six quarters to address the issue as they argue that limited degrees of freedom explained the weak exogeneity. The authors also contend that the absence of weak endogeneity does not significantly affect their equilibrium model.

Saayman (2007) estimates the BEER using three different measures of the real exchange rate (price inflation, cost inflation and labour cost adjusted real exchange rates). Also applying a VECM, the objective was to ascertain how the different real exchange rate measures would influence the equilibrium long-run exchange rate and the extent of misalignment. Relative GDP rates (measured as the log of relative GDP *per capita* of South Africa versus the United States (US)), real interest rate differentials, terms of trade, net foreign assets, the gold price, trade openness, the fiscal balance, government expenditure, gross reserves and a commodity index are used as explanatory variables in the study. The author concludes that the equilibrium exchange rate follows a similar path irrespective of the specification of the real exchange rate, although the extent of misalignment is dependent upon the deflator used. In a more recent paper, Saayman (2010) uses BEER methodology and applies Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) methods in a panel approach to identify the determinants of the long-run equilibrium exchange rate of the rand against the US dollar, British pound, Japanese yen and the euro together with episodes of exchange rate misalignment. Data from South Africa, together with the country's major trading partners (the European Union, the United Kingdom, Japan and the US) is used in the study with data from 1999 to 2008. The study finds episodes of both over- and undervaluation of South Africa's long-run equilibrium exchange rate, although the currency would revert to equilibrium within a short period. Both studies by Saayman (2007; 2010) focus on bilateral real exchange rates as opposed to the REER which is more reflective of the country's external competitiveness.

Table 2.2: Selected studies on exchange rate modelling in RSA

Author(s)	Period	Exchange rate measure	Method*	Variables**	REER Misalignment
Aron *et al*. (1997)	1970-1995	REER	Single Equation ECM	TOT, OPEN, COMM, NFA, GOVT, CAP	No
Balcilar *et al*. (2014)	1981-2013	REER	TVP-VAR	INT, INFL, GDP	No
DeJager (2012)	1982-2011	REER	VECM	PROD, INT, COMM, OPEN, CAPT, GOV	Yes
Du Plessis (2005)	1970-2002	REER	VECM	INT, PROD, COMM, OPEN, NFA, GOV	No
Fattouh *et al*. (2008)	1975-2007	REER	MS-VECM	GOLD, INT, INFL	No
Frankel (2007)	1984-2007	USD/ZAR RER	OLS	TOT, INT, COMM, CAP, RISK	No
Macdonald and Ricci (2004)	1970-2002	REER	VECM	INT, PROD, COMM, OPEN, NFA, GOV	Yes
Lacerda *et al*. (2010)	1972-2007	Nominal USD/ZAR	MS-VECM	INT, INFL, GOLD, OIL	No
Saayman (2007)	1978-2005	Bilateral USD/ZAR RER	VECM	PROD, INT, GOLD, OPEN, GOVT, RES, TOT, NFA, COMM	No
Saayman (2010)	1999-2008	Bilateral RERs	Panel DOLS & FMOLS	PROD, OPEN, CAP, GOLD, RES	No

* ECM (error correction model), TP-VAR (time-parameter VAR), VECM (Vector Error Correction Model), MS-VECM (Markov-switching Vector Error Correction Model), OLS (ordinary least squares), DOLS (dynamic ordinary least squares), FMOLS (fully modified ordinary least squares).
**INT (real interest rate differential), TOT (terms of trade), PROD (productivity differential), OPEN (external openness), COMM (commodity prices), NFA (net foreign assets), GOV (government expenditure), INFL (relative inflation), RES (foreign exchange reserves), CAPT (capital flows), GOLD (gold price), RISK (country risk indicator), GDP (relative GDP)

A recent study by De Jager (2012) follows the BEER approach and also applies a VECM to examine the various economic indicators that have an influence on the REER. The paper further seeks to model the equilibrium real exchange rate and the extent of exchange rate misalignment using data over the period 1982 to 2011. De Jager (2012) separates the explanatory variables into five broad areas: the financial sector, commodity prices and terms of trade, the fiscal balance sector, and the real and international sectors, and concludes that trends in economic fundamentals play an essential role in determining the equilibrium exchange rate. The study confirms that the REER can deviate from its equilibrium level and affirms the findings by MacDonald and Ricci (2004) that the rand was undervalued by about 20% in early 2001. De Jager (2012) cautions that the equilibrium real exchange rate level is a function of the set of fundamentals specified in the model, and accordingly notes that results would differ should the model be specified differently. One shortcoming of the study is that it makes no reference to endogeneity in the model as specified by Du Plessis (2005).

It is worth noting that previous studies on exchange rate modelling in South Africa have mainly concentrated on the bilateral and real exchange rates with a restricted focus on the REER and exchange rate misalignment. With the equilibrium exchange rate unobservable and not static as economic fundamentals change, continuous estimation of such a level is important for policy formulation. Since South Africa has also experienced several structural changes over the past few years, it is likely that the economic fundamentals that determine the equilibrium exchange rate would shift accordingly, further underscoring the importance of this study. The few studies that consider REER equilibrium levels and exchange rate misalignment apply a similar methodology (linear cointegration methods) with all of them (except for De Jager, 2012) using data predating the global financial crisis. The exchange rate, in a similar fashion to other financial variables, is subject to abrupt changes in behaviour which linear modelling methods sometimes cannot capture appropriately. Nonlinear models, on the other hand, are better suited to capture sharp and discrete changes in the economic mechanism that generates the data being studied, hence the increasing popularity of Markov switching frameworks in modelling financial time series. Since exchange rate misalignment could be considered to exhibit two distinctly separate sets of behaviour, a regime switching methodology – which captures these characteristics – might be more appropriate to model such behaviour.

This study therefore adds to the literature in the following aspects: firstly, more recent data is applied to estimate the equilibrium REER and exchange rate misalignment. Secondly, the subject of exogeneity in the equilibrium exchange rate model is addressed to ensure a proper specification is obtained. Finally, the study uses a nonlinear regime switching methodology to model the misalignment behaviour. With the exception of Terra and Valladares (2010) who include South Africa in a panel specification (with data from 1960 to 1998), the author has no knowledge of a study that has used a similar approach. The method chosen hence allows this study to make a contribution to the empirical literature by attempting to capture the rand's misalignment dynamics as originating from one of two distinct regimes, namely over- or undervaluation episodes. Such an approach also has the potential to capture structural breaks in exchange rate movements that are driven by both domestic and international factors. Ang and Timmermann (2011: 1) note that regime switching models "can match narrative stories of changing fundamentals that can only be interpreted *ex post*, but in a way that can be used for *ex ante* real time forecasting and other economic applications".

2.4 EMPIRICAL MODEL FOR THE REAL EFFECTIVE EXCHANGE RATE

The empirical approach followed in the study is adopted from Terra and Valladares (2010) where exchange rate misalignment is measured as the difference between the observed REER and its equilibrium level. Cointegration techniques are used to estimate a long-run relationship between economic fundamentals and the REER (BEER framework is applied). Finally, a Markov regime switching method is employed to model the behaviour of the misalignment series as a possible stochastic autoregressive process governed by two states with different means and variances. Terra and Valladares (2010) note that should the regime switching method produce a good fit for the misalignment and distinct regimes can be identified, the probability that the exchange rate was either under- or overvalued at each point in time can be inferred. The data used in the study is quarterly from 1985 to 2014 and mainly captures the post-democratisation period, which is associated with increased integration of South Africa's economy with the global economy and highly liberal economic policy.

2.4.1 BEER framework and exchange rate misalignment

The BEER approach focuses on modelling the behavioural link between real exchange rates and the appropriate economic variables using a reduced-form equation. This method is aimed at identifying statistically significant long-term drivers of the REER and subsequently modelling the exchange rate in a behavioural context. The reduced-form equation of the REER may be expressed as follows (Baak, 2012; Gan *et al.*, 2013):

$$LREER_t = \beta' F_t + \epsilon_t \quad \text{…(2.1)}$$

where LREER$_t$ is the log of the REER, *F* represents a vector of values of economic fundamentals that have long-run persistent effects on the equilibrium real exchange rate and ϵ_t is the random disturbance term.

Empirical studies differ on the final choice of economic fundamentals that drive the exchange rate in the long run. For the purpose of this study, the variables that enter the model were carefully selected based on economic theory, the empirical literature, data availability and – most importantly – South Africa's economic (and political) history which has had a profound impact on exchange rate movements. From being the largest gold producer globally in the 1970s, experiencing economic and political sanctions in the 1980s, the transition to popular democracy in 1994 and rising to become one of the leading global emerging markets currently attracting significant capital flows, the country's economic fundamentals and the factors influencing the exchange rate have evolved over time. The study considered the following variables for inclusion in the long-run REER model as mainly identified in the literature[4]:

Real interest rate differential

The real interest rate differential between South Africa and its major trading partners captures developments in the financial sector and theoretically reflects the uncovered interest parity condition. An increase in South Africa's real interest rates relative to the country's main trading partners should cause the rand to appreciate in the long run through an increase in foreign capital inflows The variable is calculated as the real yield differential between the 10-year South African government bond and the moving weighted average real 10-year bond yield of the country's major trading partners (the US, Germany for the Eurozone, the UK and Japan). The percentage change in CPI is used to deflate the nominal yields. Although China's role as South Africa's trading partner became

[4] Other variables that were considered include the gold price, the commodity price index, government debt to GDP ratio, RSA's GDP per capita, foreign exchange reserves and the NEER. These variables were chosen based on the previous studies and explanatory variables listed in Table 2.2 above.

more prominent after 1999, Chinese real interest rates are excluded due to the country's closed capital markets over most of the period studied. Other studies (e.g. De Jager, 2012) use the interest rate differential between South Africa and the United States since the US has the largest open and liquid capital markets globally.

Net capital flows

Net capital flows provide a reflection of a country's external position and, in principle, a surge in capital inflows improves the country's net external position, thus causing the exchange rate to appreciate over time (positive relationship). Net capital flows are calculated in the study as the sum of net changes in unrecorded transactions (errors and omissions) and the net balances on the capital transfer and financial accounts, expressed as a percentage of GDP. This description of net capital flows correctly captures the change in the country's liabilities as a result of transactions by both locals and foreigners within the balance of payments. With the gradual relaxation of exchange controls (i.e. capital controls) after 1994, and following the integration of the country with the global economy and South Africa's highly developed financial markets, capital flows have become an important economic indicator[5]. This measure of net capital flows is adopted from Rangasamy (2009).

Productivity differential

This variable represents the Balassa-Samuelson effect, which suggests that if a country experiences an increase in the productivity of the tradable sector relative to its trading partners, this would cause an appreciation in the exchange rate (Macdonald & Ricci, 2004). With productivity not easily observable and problematic to measure, previous studies (e.g. Gan *et al.*, 2013; Wang, Xiaofeng & Soofib, 2007; MacDonald & Ricci, 2004) are followed where relative real GDP *per capita* is used to capture the Balassa-Samuelson effect. The variable in this study is calculated as the moving weighted average GDP *per capita* of the country's main trading partners less South Africa's real GDP *per capita*. *A priori*, an increase in South Africa's GDP relative to the country's major trading partners should cause the rand's REER to appreciate.

Terms of trade

Terms of trade epitomise one of the channels for the transmission of global macroeconomic shocks to the local economy and the indicator is calculated as the price of a country's exports relative to the price of its imports. The effect of terms of trade on the REER occurs through the income and substitution effects, with the net impact depending on the relative strength of each of the factors since they work in opposite directions. Although theoretically important as a determinant of the REER in the long run, the direction of the impact of terms of trade on the exchange rate remains largely unclear. As South Africa is a relatively small open economy, it is highly exposed to terms of trade

[5] This indicator can also capture developments in relative interest rate differentials. South African markets experienced increased capital inflows in search for yield after the global financial crisis following aggressive monetary policy easing and quantitative easing by developed country central banks.

shocks that occur mainly via the trade channel. The terms of trade variable used in the study includes the price of gold since the rand has been historically associated with movements in the price of bullion given the country's role as one of the largest producers of the yellow metal.

External openness

Calculated as the sum of exports plus imports divided by GDP, this variable measures the extent to which the country is connected to the rest of the world and is a reflection of trade liberalisation. Openness has an influence on the exchange rate since its extent affects the prices and volumes of exports and imports that are sensitive to the exchange rate. The direction of influence of trade openness on the exchange rate is inconclusive in the empirical literature but generally depends on the weight of imports versus exports in the economy. For example, MacDonald and Ricci (2004) find that an increase in South Africa's external openness is associated with a depreciation in the REER.

Government expenditure

The ratio of government expenditure to GDP is a popular explanatory variable in REER models and represents a proxy for demand pressures in the economy. The empirical literature on the sign of the effect of government expenditure on the real exchange rate is inconclusive as it depends on whether extra government funds are channelled towards tradable or nontradable goods. A permanent expansion in government expenditure that increases demand for nontradable goods would induce an appreciation in the REER, whilst government expenditure channelled towards imports of, for example, capital equipment for infrastructure development, would cause the exchange rate to depreciate (Goldfajn & Valdés, 1999). In the aftermath of the 2007 global financial crisis, the South African government used countercyclical fiscal policy as one of the ways in which to stimulate economic growth. The impact of this strategy on the exchange rate would be interesting to note. The following equation could therefore be estimated to determine the equilibrium REER:

$$LREER_t = \alpha + \beta_1 PROD_t + \beta_2 TOT_t + \beta_3 OPEN_t + \beta_4 INT_t + \beta_5 CAP_t + \beta_6 GOV_t + \epsilon_t \qquad \text{...(2.2)}$$

where PROD is a proxy for productivity differentials, TOT is terms of trade, OPEN is external openness, INT is real interest rate differential, GOV is government expenditure and CAP is a capital flow variable. Equation 2.2 therefore aims to capture the long-run relationship between the REER and the country's key economic fundamentals. The final model adopted included the following variables: terms of trade (including gold), external openness, net capital flows and government expenditure. An issue to note is that most of these variables are associated with the country's external sector, which is a reflection of the close integration of South Africa with the global economy mainly through trade and capital flows. All these variables are used in previous South African studies (e.g. MacDonald and Ricci, 2004; De Jager, 2012)[6].

2.4.2 Econometric procedure

Since we are dealing with nonstationary time series, the Johansen (1995) cointegration procedure is used to estimate the long-run relationship amongst the series. After the identification of a cointegrating equation and confirmation that the exchange rate is endogenous in the long-run model based on a weak exogeneity test, a single equation model is then used to estimate the cointegration relationship. In line with Goldfajn and Valdés (1999), the Dynamic Ordinary Least Squares (DOLS) methodology advocated by Saikkonen (1992) and Stock and Watson (1993) is applied to estimate Equation 2.2. The DOLS method is preferred to the VECM since it augments the cointegration equation with leads and lags of first differences of the explanatory variables. This improves the estimation results and thus corrects for serial correlation in the residuals and possible endogenous fundamentals (Goldfajn & Valdés, 1999). Application of this methodology is intended to follow closely the procedure employed by Terra and Valladares (2010), and allows for the applicability of the Markov regime switching model to be compared with a specific reference to South Africa, especially taking into account the shocks to the exchange rate seen in 2001 and 2009. The DOLS equation is specified as follows:

$$LREER_t = \beta F_t + \sum_{j=-k_1}^{k_2} \gamma_i \Delta F_{t-j} + e_t \qquad \ldots(2.3)$$

where $LREER_t$ is the dependent variable (REER), F_t the vector of explanatory variables, and k_1 and k_2 the numbers of leads and lags respectively. The stationarity of the residuals (ϵ_t) will further confirm the presence of cointegration with the order of the leads and lags consistent with the number of lags identified in the Johansen cointegration equation (2.2) as per the Akaike information criterion (AIC) and the Final Prediction Error (FPE) test. A misalignment (Mis_t) in the exchange rate under this model would therefore be represented by the difference between the actual (observed) real exchange rate and the equilibrium REER given by the value of the economic fundamentals as follows:

$$Mis_t = LREER_t - \underline{LREER_t{}^*} \qquad \ldots(2.4)$$

where $\underline{LREER_t{}^*}$ represents the estimated equilibrium REER from Equation 2.3. A Markov switching model is then applied to study the dynamics of the REER misalignment and the probability of the exchange rate to be in one regime (e.g. overvaluation) and the likelihood of switching from one regime to another.

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[6] Other variables that were considered include the gold price, the commodity price index, government debt to GDP ratio, South Africa's GDP per capita, foreign exchange reserves and the NEER as per the studies on South Africa identified in Table 2.2.

2.4.3 Markov switching model and REER misalignment

Hamilton (1989) proposed that the Markov switching model be applied to time series data or variables that are likely to undergo shifts from one type of behaviour (regime) to another and back again, with the variable that drives the regime shifts unobservable (Brooks, 2008). The model assumes there exist *k* regimes or states of nature in the data generating process (e.g. two exchange rate episodes in the current study, namely over- and undervaluation), normally distributed with mean μ_i and variance σ^2_i (different means and variances; μ_1, σ_1^2 in regime 1 and μ_2, σ_2^2 in regime 2 for a process with two regimes). Each state is assumed to follow a Markov process such that the probability of being in state *i* at period *t* is conditional upon the state at period *t-1*. Maitland-Smith and Brooks (1999) note that the strength of the model lies in its flexibility and capability to capture changes in the mean and variances between the state processes.

The model that assumes two regimes differentiated by mean and volatility shifts can be specified as follows (Guo, Brooks & Shami, 2010):

$$Y_t = \alpha_1 S_t + \alpha_2(1 - S_t) + [\sigma_1 S_t + \sigma_2(1 - S_t)]\epsilon_t \text{ where } \epsilon_t \sim N(0,1) \qquad \ldots(2.5)$$

where Y_t is the variable of interest (exchange rate misalignment series in the study) and S_t is a binary variable denoting the unobservable regime in the system (state). A Markov chain that governs the evolution of the unobserved state variable (S_t) that has two regimes would have the following transition probabilities (see Engel & Hamilton, 1990; Brooks & Persand, 2001):

$$Prob[S_t = 1|S_{t-1} = 1] = p_{11}$$
$$Prob[S_t = 2|S_{t-1} = 1] = 1\text{-}p_{11}$$
$$Prob[S_t = 2|S_{t-1} = 2] = p_{22}$$
$$Prob[S_t = 1|S_{t-1} = 2] = 1\text{-}p_{22}$$

where p_{11} and p_{22} indicate the probability of being in regime 1 given that the system was in regime 1 in the previous period, and the probability of being in regime 2 given that the system was in regime 2 in the previous period, respectively. The transition probabilities (1-p_{11} and 1-p_{22}) denote the likelihood of shifting from regime 1 in state *t-1* to regime 2 in period *t* (1-p_{11}) and the probability of shifting from state 2 to state 1 (1 - p_{22}) between t_{-1} and *t*. Such a model allows me to estimate the probability that the exchange rate's misalignment series was at a given regime (under- or overvalued) at any point in time. Important parameters of the model that require estimation are μ_1, μ_2, σ_1^2, σ_2^2, p_{11} and p_{22}. Hamilton (1989) provides the algorithm for drawing probabilistic inference (using maximum likelihood estimation) about whether and when the shifts in the series' behaviour might have taken place based on the observed behaviour in the form of a nonlinear interactive filter. Since the regimes are unobservable, inferences about their odds are based on the observed data. The algorithm chooses the parameter values in a manner that maximises the log-likelihood function for the observed series (Bazdresch & Werner, 2005).

Following previous studies (including Engel, 1994; Pinno & Serletis, 2007; Nikolsko-Rzhevskyy & Prodan, 2012), the exchange rate's behaviour (precisely the misalignment series in this study) is modelled as a two-state Markov switching random walk model that allows both the drift term and variance to take two different values during episodes of over- and undervaluation. This permits me to model exchange rate misalignment in any given quarter as being drawn from one of the two regimes, allowing the parameter estimates to be used to infer which regime the exchange rate is in. Terra and Valladares (2010) note that the MSM allows exchange rate misalignment to be modelled as a first order Markov process with the following transition probability matrix:

$$P = \begin{bmatrix} Poo & Pou \\ Puo & Puu \end{bmatrix}$$

where *Poo* is the probability that the exchange rate will remain in the state of overvaluation, *Puu* the probability of remaining in a state of undervaluation, *Puo* the probability of transition from an under- to an overvaluation regime, and *Pou* the likelihood of transition from over- to undervaluation.

2.5 EMPIRICAL RESULTS

2.5.1 Unit root tests

Prior to model estimation and in line with normal methodology for dealing with time series data, unit roots tests were carried out on the variables in order to understand the nature, behaviour and order of integration of all the series. The Augmented Dickey Fuller (ADF) test is used as the benchmark method to check for stationarity of the series. Given the fact that conventional unit root methodology such as the ADF test is not likely to identify non-stationarity when a series has a structural break (Perron, 2006), the Breakpoint Unit Root Test is used to supplement and confirm results from the ADF tests and all the results are reported in Table 2.3 below. The Break Point Unit Root Test is robust in the presence of a structural break in the series being studied and should enhance plausibility of the conclusions about the data generating process in the series being studied.

The unit test results indicate that all the variables are non-stationary at level with the variables stationary at first difference (i.e. I(1)). The Breakpoint Unit Root Test identifies 1998Q1 as a break date for the dependent variable (*LREER*) and this coincides with the beginning of an exchange rate depreciation episode as identified in Figure 2.1. The unit root test results suggest that the variables can be considered as integrated of order one (i.e. I(1)) at a 1% level of significance. A graphical inspection of the series and results from the conditional Dickey-Fuller tests are also used to cater for the choice of deterministic trends in the series and the choice of the most appropriate model[7]. Consequent to these unit root tests results, the next step was to test for the possible presence of a cointegrating relationship amongst the variables.

[7] The variables; terms of trade, external openness and the government expenditure variables appear to exhibit the presence of trends in the data generating process. The appropriate specification chosen for the study and hence the results in Table 2.4 are for a model with a linear intercept and trend.

Table 2.3: Unit root test results

Augmented Dickey-Fuller					
Level			**First Difference**		**Conclusion**
Variable	***Intercept***	***Intercept & Trend***	***Intercept***	***Intercept & Trend***	
Lreer	-2.69*	-3.08	-11.26***	-11.22***	I(1)
Lgdp	-2.52	-1.68	-10.01***	-10.48***	I(1)
ltot_ingold	-0.39	-1.62	-5.68***	-5.70***	I(1)
Lopen	-1.60	-2.91	-12.44***	-12.43***	I(1)
Lgovt	-2.62*	-2.55	-13.88***	-13.92***	I(1)
k_flows	-2.13	-2.46	-8.21***	-8.18***	I(1)
real_int	-2.08	-2.17	-5.37***	-5.36***	I(1)
Breakpoint Unit Root Test					
Level			**First Difference**		**Conclusion**
Variable	***Intercept***	***Intercept & trend***	***Intercept***	***Intercept & Trend***	
Lreer	-3.66	-3.77	-11.73***	-11.76***	I(1)
Lgdp	-3.54	-3.64	-14.75***	-15.84***	I(1)
ltot_ingold	-3.11	-3.15	-16.34***	-16.30***	I(1)
Lopen	-3.25	-4.16	-13.21***	-13.25***	I(1)
Lgovt	-3.49	-4.96**	-14.41***	-14.22***	I(1)
k_flows	-3.76	-3.88	-8.78***	-8.76***	I(1)
real_int	-3.97	-4.91*	-7.71***	-7.71***	I(1)

Note: *, **, *** denote significance at 10%, 5% and 1% respectively
Null hypothesis is there is unit root in all cases.

2.5.2 Tests for cointegration

The Johansen (1995) procedure is used to test for the existence of cointegration among the variables. The objective is to identify variables that have a long-run equilibrium relationship with the exchange rate. The economic indicators that enter the long-run equation were thus carefully chosen based on economic theory, correlation matrices, endogeneity of the exchange rate in the model and the correct signs of the coefficients. The appropriate lag length was chosen based on the information criteria: the Akaike information criterion (AIC), the Schwarz information criterion (SIC) and the Hannan-Quinn information criterion (HQ). The lag length that produced the most meaningful results is selected. Table 2.4 below presents a summary of the Johansen cointegration test result.

Table 2.4: Cointegration test results

Sample (adjusted): 1985Q4 2014Q4
Included observations: 117 after adjustments
Trend assumption: Linear deterministic trend (restricted)
Series: LREER LTOT_INGOLD LOPEN K_FLOWS LGOVT
Lags interval (in first differences): 1 to 2

		Trace test			Maximum Eigen Value Test		
Hypothesised no. of CE(s)	**Eigenvalue**	**Trace statistic**	**0.05 Critical value**	**Prob.****	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob.****
None	0.31	110.26*	88.80	0.00	43.61*	38.33	0.01
At most 1	0.21	66.65*	63.87	0.02	27.93	32.11	0.14
At most 2	0.18	38.71	42.91	0.12	23.84	25.82	0.08
At most 3	0.08	14.87	25.87	0.58	10.02	19.38	0.61
At most 4	0.040	4.84	12.51	0.61	4.84	12.51	0.61

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Both the trace and maximum eigenvalue tests (Table 2.4) endorse the existence of at least one cointegrating relationship amongst the variables, confirming that over the long run the REER moves together with the terms of trade (including gold price), external openness, government expenditure and net capital flows[8]. The trace test found two cointegrating equations while the maximum eigenvalue test shows one cointegrating vector. Both options were explored and the model that produced the most plausible results was chosen. The selected model has more theoretically relevant variables with economically meaningful results and, most importantly, one in which the exchange rate variable is endogenous. The Wald test is used to conduct the weak exogeneity test, whereby a zero restriction is imposed on the respective error correction terms of each variable (Table 2.5 below).

Table 2.5: Weak exogeneity test

Variable	Chi Square	Probability
LREER	16.197	0.00
LTOT_INGOLD	12.993[#]	0.00
LOPEN	2.650	0.10
K_FLOWS	0.030	0.86
LGOVT	1.475[#]	0.22

[#]error correction coefficient is positive and renders the model inappropriate

Source: Author's own calculations

[8] The maximum eigenvalue test shows that one cointegration relationship exists amongst the variables under a model that assumes there is a linear deterministic trend in the data and an intercept in the cointegrating equation (model of interest in the study) whilst the trace statistic shows two cointegrating equations.

The results from the VECM estimates have the correct signs and all appear within reasonable expectations. The adjustment factor of the cointegration equation (speed of adjustment) is found to be negative (-36%) and statistically significant[9]. This adjustment (error correction) coefficient indicates that 36% of disequilibrium in the exchange rate is corrected for in the first period, 36% of the remaining disequilibrium is corrected for in the second period, then 36% of the remaining disequilibrium is corrected for in the third period, and so forth. Most importantly, a weak exogeneity test confirms that the REER is endogenous in the model; the results indicate a sufficiently large Chi-square statistic (16.197) with a p-value of 0.00. It is also worth noting the exchange rate is the most weakly endogenous variable in the system compared to the other variables, thus affirming the suitability of such a cointegration relationship. Confirmation of endogeneity implies that adjustments towards the equilibrium relationship in the model occur through the exchange rate (Du Plessis, 2005). The autocorrelation LM test provides evidence that there is no serial correlation in the model for the lag chosen (LM-Stat, 25.38; Prob, 0.44). Such results allowed us to estimate the cointegrating vectors by means of a single equation method.

Table 2.6: Long-run estimated equation results[10]

Results of BEER model (DOLS)[11]						
Variable	**LTOT_INGOLD**	**LOPEN**	**K_FLOWS**	**LGOVT**	**CONSTANT**	**@TREND**
Coefficient	0.8157 (7.3488)	-0.8533 (-15.5951)	0.5839 (6.2626)	-0.3677 (-3.3135)	5.5924 (25.8426)	-0.0016 (-6.3468)
p-value	0.0000	0.0000	0.0000	0.0013	0.0000	0.0081

T-values are reported in parentheses below the coefficients.
White heteroscedasticity-consistent standard errors and covariance are applied.

Subsequent to confirmation of a cointegration relationship among the variables, a long-run equilibrium exchange rate was estimated and its movements compared to the actual REER to ascertain the possible presence of misalignment in the rand. The DOLS method is used to estimate the long-run cointegrating equation and the results are presented in Table 2.5 above. Hossfeld (2010) notes that the DOLS method improves robustness of the estimates as it caters for potential endogeneity among the explanatory variables. The lead (1) and lag (1) terms included in the DOLS regression have the purpose of making its stochastic error term independent of all past innovations in the stochastic regressors (Eviews 9 User Guide II). Newey and West's (1987) Heteroscedastic

[9] The speed of adjustment identified in this model is faster at 36% than found in previous studies: De Jager (2012) found 28.50%, MacDonald and Ricci (2004) obtained 8%.
[10] Since the main objective is estimating the long-run relationship, the focus is on the long-run relationship, with a high degree of reliance on the plausibility of the VECM model. Model diagnostics for the DOLS are not reported since the short-run dynamics (leads and lags) are used for computing the residuals used. Caution in interpreting such measures is therefore warranted (Eviews 9 Users Guide II).
[11] For comparison purposes, the results of the VECM were as follows: coefficients and t-statistics respectively; LTOT_INGOLD: 1.019 (6.44), LOPEN: -0.940 (14.01), K_FLOWS: 0.587 (4.51) and LGOVT: -0.545 (3.54) and are not materially different from the DOLS results.

and Autocorrelation Consistent (HAC) covariance matrix, whose standard errors are robust, are used to estimate the model using the Eviews 9 package. Lastly, unit root tests are performed on the residuals of the DOLS model in order to confirm that the stochastic error term of the model is stationary such that the regression is not spurious[12] (Choi *et al.*, 2008).

Table 2.6 provides the estimated long-run REER equation of the rand obtained from the cointegrating vector. The short-run coefficients of the leads and lags of the cointegrating regressors are not reported since the main interest is in the long-run parameters. All the variables in the cointegrating vector are statistically significant and exhibit the correct signs, implying that the selected variables explain movements of the REER in the long run. The trend coefficient in the model is also statistically significant, confirming the presence of a trend in the cointegrating variables. The results suggest that a 1% increase in the country's terms of trade that includes the gold price will lead to an appreciation in the REER of about 0.82%. A similar directional relationship is observed between capital flows and the exchange rate. Increases (1%) in external openness and government expenditure, however, cause depreciation in the exchange rate of 0.85% and 0.37% respectively. The results obtained are in largely line with conclusions from previous studies such as MacDonald and Ricci (2004) and De Jager (2012).

Since the principal concern of the study is to assess the extent to which the rand is misaligned, the permanent value[13] of the estimated REER from the cointegrating relationship is used to define the equilibrium REER. Following the previous work of Gan *et al.* (2013), De Jager (2012), and Iossifov and Loukoianova (2007), the permanent value of the estimated equilibrium exchange rate is extracted using the Hodrick-Prescott (HP) filter. Misalignment in the exchange rate, defined as the deviation of the actual REER from the HP-filtered equilibrium level, is therefore estimated as:

$$Mis_t = REER_t - REER_t(HP\_) \qquad \ldots(2.6)$$

Figure 2.2(a) shows the actual REER versus the equilibrium (HP-filtered) REER over the period 1985 to 2014, with the extent of misalignment (expressed as the percentage deviation of the actual REER from the HP-filtered estimated equilibrium REER) presented in Figure 2.2(b). Figure 2.2 confirms that the exchange rate deviates from its equilibrium level over time with the historical misalignment pattern witnessed confirming similar observations from previous studies including De Jager (2012), Saayman (2010) and MacDonald and Ricci (2004). The study affirms an extreme undervaluation in the exchange rate at the end of 2001 (more than 20%) and between 2008 and 2009 (about 17% in 2008Q4). A significant correction beginning in 2002 led to the exchange rate to be overvalued by close to 15% by 2006. Some undervaluation in the REER is also observed in 2014. The plot of the misalignment series (Figure 2.2(b)) indicates the presence of abrupt changes or shifts in the direction

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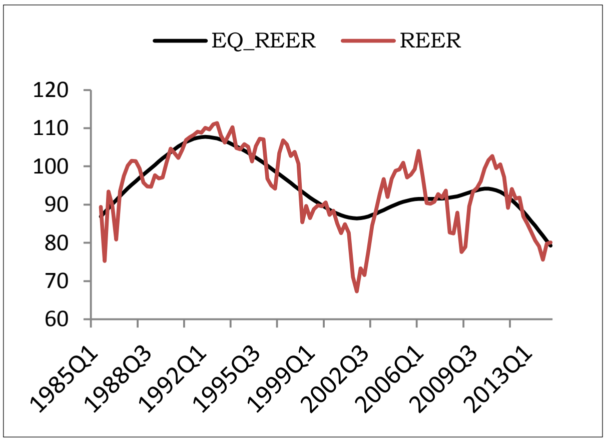
[12] ADF (and Breakpoint Unit root tests are used to confirm stationarity of the error term for the DOLS model.

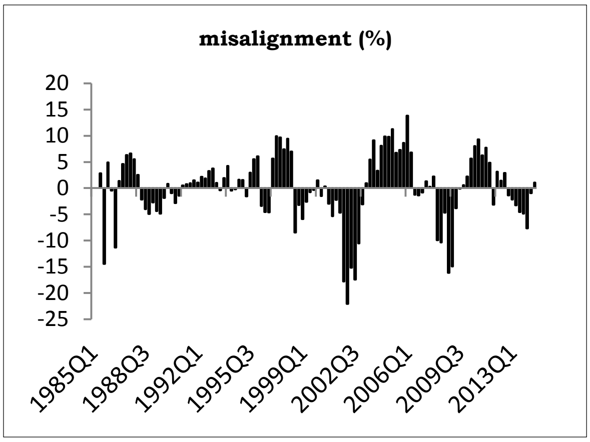
[13] Since the exchange rate is subject to short and random disturbances (noise or volatility), smoothing techniques need to be applied to neutralise the volatile fluctuations and obtain a stable BEER that can be termed "permanent" using the Hodrick-Prescott (HP) filter.

of misalignment and long swings in the deviation of the REER from its equilibrium level. For example, following an undervaluation exceeding 20% in 2002, the exchange rate moved back quickly into equilibrium and was overvalued by about 10% in 2003. Similar moves are observed between 2008 and 2010 when the global financial crisis caused a steep decline in the currency in 2008 before a recovery was observed in 2010.

An analysis of the misalignment series indicates that the exchange rate has been on average more undervalued over the period studied with the series both significantly skewed and leptokurtic. The Jarque-Bera test statistic confirms the departure of the data from normality and provides motivation for the use of a method of analysis with a time-varying component where the current estimates of both the mean and variance of the series are permitted to depend, in some fashion, upon their previous values. As Terra and Valladares (2010) note, a modelling method that identifies whether distinct regimes for misalignment (under- versus overvalued states) exist might provide a better fit for the data (misalignment series). The MSM applied in the study endogenously determines the possible presence of over- and undervaluation episodes that may be regarded as different deviations from the equilibrium exchange rate. Results from the MSM model are presented and discussed below.



(a)



(b)

Figure 2.2: Actual versus equilibrium REER and misalignment

Source: Author's own calculations

2.5.3 Markov regime switching model results

In the MSM framework employed, the misalignment series is used as a dependent variable in the model in order to derive the probability of being in a specific regime at a particular point in time. An important feature of the MSM is to test the hypothesis that the data was generated by a mixture of two normal distributions such that the mean parameters from the different regimes are significantly different. In the current study, the model should account for two states in the misalignment series, namely REER over- and undervaluations. Table 2.7 presents the results of the MSM and the key parameters of the model which confirm the existence of two exchange rate misalignment episodes.

The estimated parameters confirm that the mean values of the misalignment series are significantly different under the alternative regimes: the state of overvaluation has a positive mean ($\mu_2 = 7.7067$) whilst the undervaluation episodes have a negative mean ($\mu_1 = -2.2493$). The results also confirm that the undervaluation regime has a higher volatility (5.608128) than the overvaluation episode (2.302109). This should be expected since currency depreciation episodes in South Africa have been mainly abrupt and coincided with significant volatility in the nominal exchange rate. Such a finding is also consistent with the leverage effects that are mainly associated with exchange rate volatility, that is, negative shocks to the exchange rate leads to higher volatility compared to positive shocks of a similar magnitude (Brooks, 2008).

Table 2.7: MSM results

Parameter	Estimate	z-Statistic	Prob
μ_1	-2.2493***	-3.4315	0.0006
μ_2	7.7067***	13.9658	0.0000
σ^2_1	5.6081***	21.9713	0.0000
σ^2_2	2.3031***	5.1292	0.0000

Dependent variable is Misalignment series

The probabilities (fixed) of transition from one regime to another are expressed in the matrix below:

$$P = \begin{bmatrix} Puu & Puo \\ Pou & Poo \end{bmatrix} = \begin{bmatrix} 0.95 & 0.05 \\ 0.17 & 0.83 \end{bmatrix}$$

The values of P_{uu} and P_{oo} respectively denote the probability of staying in regime 1 (undervaluation) given that the exchange rate was undervalued in the previous quarter, and the probability of staying in regime 2 (overvaluation) given that the exchange rate was in regime 2 previously. The parameters (P_{uu} and P_{oo}) have high values and indicate some stability as they suggest that if the exchange rate is in either regime 1 or 2, it is highly likely to remain in that state in the next period (Pinno & Serletis, 2007). Notable in the MSM results is the higher probability of the exchange rate being undervalued and the fact that undervaluation episodes seem to have on average longer durations (about 22 quarters versus 6 quarters for overvaluation episodes) over the sample period. This is confirmed when plotting the estimates from the model of the probabilities of being in either of the two regimes over the full sample period.

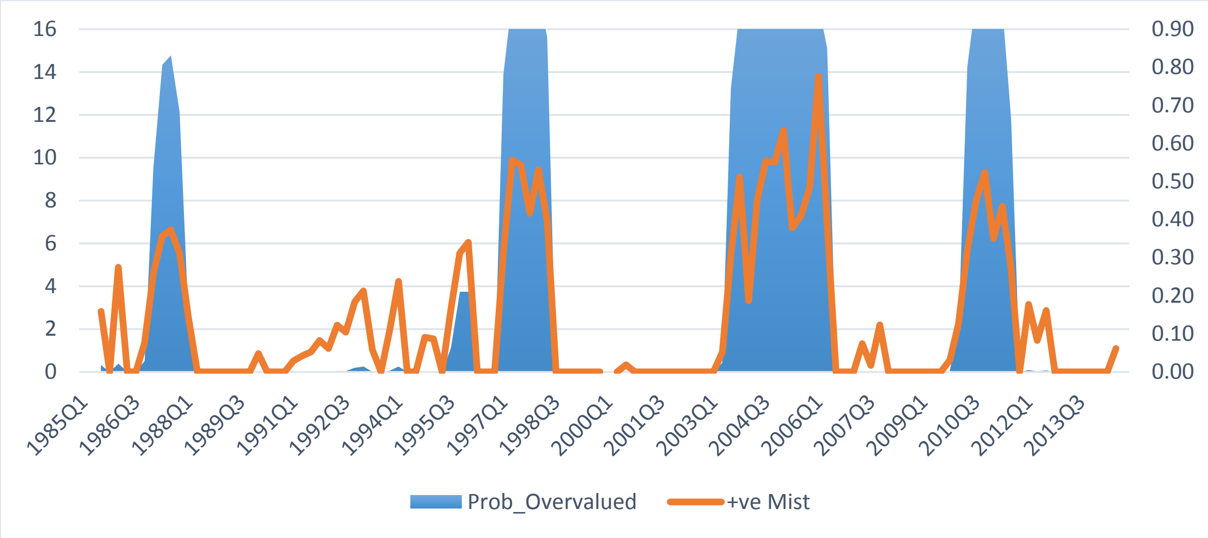


Figure 2.3: Probability of being in regime 2 (REER overvalued)[14]

P(S(t) = 2) smoothed probabilities

Figures 2.3 and 2.4 plot the inferred probabilities (smoothed) from the MSM of being in regimes 1 and 2 and compare such episodes with the misalignment series estimated (solid lines) from the long-run cointegrating relationship. The MSM framework correctly identifies both under- and overvaluation episodes and confirms that the REER was more often undervalued than overvalued in the period 1985-2014. For example, the model confirms the exchange rate was in regime 2 (overvalued) between 2002 and 2003; in regime 1 (undervalued) between 1998 and 2002. The MSM correctly tracks the misalignment episodes as determined by the equilibrium exchange rate model and indicates that the exchange rate was most likely undervalued (in regime 1) in 2014. When compared to Terra and Valladares (2010), the results from this study appear superior since the existence of two exchange rate regimes with means and variances significantly different under each regime can be confirmed. In their main findings, South Africa was included amongst countries where the model identified a regime with a mean quite close to zero and another in which it was very far from zero (positive mean). Terra and Valladares (2010) are also unable to able to identify a relation between exchange rate volatility and its mean (i.e. if undervaluation regimes have higher or lower variance than overvaluation ones) – a phenomenon that is confirmed in this study.

[14] Prob_Overvalued and Prob_Unvervalued mean the probability of being in regime 2 (overvaluation) and probability of being in regime 1 (undervaluation) respectively. +ve Mist and –ve Mist are the estimated overv- and undervaluation series (%) from the BEER model.

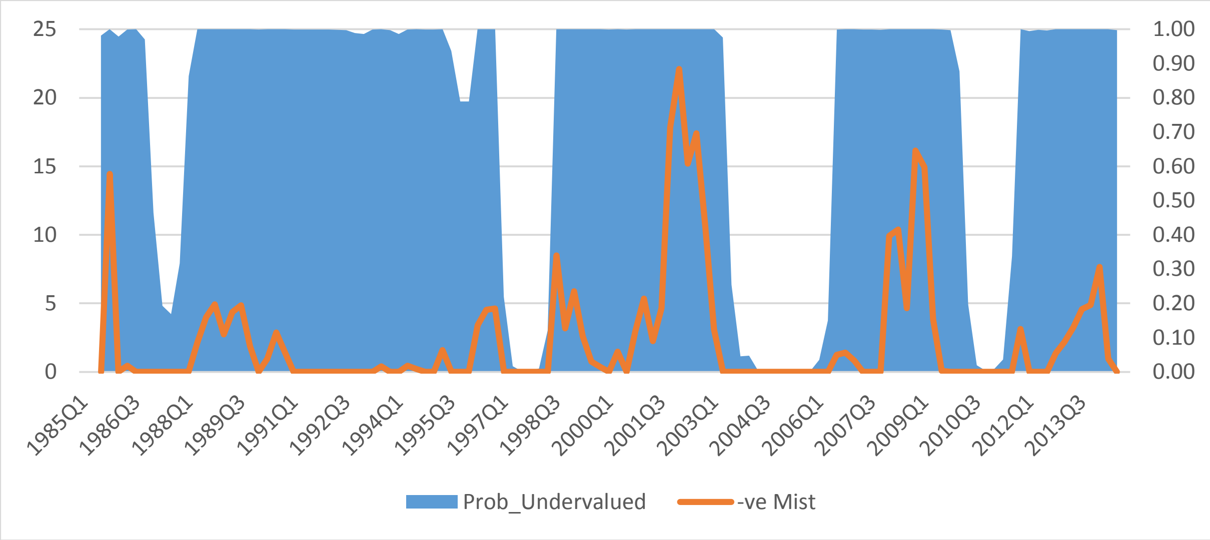


Figure 2.4: Probability of being in regime 1 (REER undervalued)

P(S(t) = 1) smoothed probabilities

2.6 CONCLUDING REMARKS AND POLICY IMPLICATIONS

The REER plays a key role in the macroeconomic performance of the country and an analysis of its equilibrium level and the variables that determine this level is essential. Applying the BEER approach, this study finds evidence that a long-run equilibrium relationship exists between the rand's REER and economic variables that include the terms of trade, external openness, capital flows and government expenditure. Frequent deviations of the observed exchange rate from the estimated equilibrium level are found over the period studied and these are interpreted as exchange rate misalignments. The MSM correctly captures the misalignment over the sample period as distinct episodes of over- and undervaluation. Four overvaluation episodes are identified (1986-1988; 1997-1998; 2003-2006 and 2010-2012) with the study indicating that the exchange rate was undervalued (to differing extents) over most of the period studied. Extreme undervaluation in the exchange rate is recorded in 1998-2003, and during the midst of the global financial crisis in 2007/2008. Results of the study also indicate that the exchange rate was undervalued between 2013 and 2014.

The first key finding from the study is the identification of economic variables that form a long-run cointegrated movement with the exchange rate (i.e. the terms of trade, external openness, government expenditure and capital flows). Should policymakers wish to use the exchange rate as a policy tool, one of the key prerequisites for that is an understanding of the drivers of the equilibrium exchange rate such that any deliberate actions to deal with exchange rate misalignment would have to focus on the underlying fundamentals influencing the exchange rate. For example, with net capital inflows associated with an appreciation in the exchange rate, when faced with exchange rate overvaluation, the SARB could consider either reducing interest rates or applying a temporal tax on capital inflows that are deemed to be short-term or volatile in an effort to drive a policy-induced depreciation in the exchange rate. The starting point, however, is for the SARB to formally acknowledge the REER as part of its policy toolkit and have a view on where the level of the exchange rate is relative to its equilibrium. Although the study is able to identify economic variables that have a long-run relationship with the exchange rate, as noted by De Jager (2012), the equilibrium level of the exchange rate is highly influenced by the choice of variables entering the exchange rate model. Furthermore, with South Africa's economy constantly susceptible to structural changes, the period chosen for a particular study might also influence the results given the changing relative importance of economic indicators[15].

Important to note is the fact that most of the variables used to explain the equilibrium exchange rate of the rand are associated with the external sector (external openness, terms of trade and net capital flows). Although this is not entirely a problem since the exchange rate is endogenous in the equilibrium model, it raises the possibility that the equilibrium exchange rate of the rand could be better explained using Williamson's (1993, 1994) Fundamental Equilibrium Exchange Rate approach. This methodology emphasises the balance on the current account such that the equilibrium real exchange rate is the one that ensures the current account adjusts back to its norm over time. An extension of the study could use this approach to model the rand's misalignment over time and compare the results with findings from this study. It is also crucial within the same context to note the close integration of South Africa with the global economy and the susceptibility of the country to global trade patterns and capital flows, especially over the period chosen for the study. The variables chosen also compare well to those used in previous studies, for example MacDonald and Ricci (2004) and De Jager (2012).

Lastly, on the topic of variable selection, a notable omission from the final model in this study is a variable that captures the Balassa-Samuelson effect. Productivity differentials are inherently difficult to measure and both studies that have estimated REER misalignment in South Africa (MacDonald and Ricci (2004) and De Jager (2012) use relative GDP per capita differentials. De Jager (2012) used the differential between South Africa and the United States, a measure which could be deemed inadequate given that the US is not South Africa's largest trading partner. MacDonald and Ricci (2004) use relative GDP between South Africa and the country's major trading partners as a proxy for productivity differentials. Although the variable is statistically significant in their model, they apply data from 1970 to 2002 whereas the current study uses data from 1980 to 2014. South Africa's trade patterns and the factors influencing the exchange rate were different between these two periods and may therefore possibly explain the difference in conclusions when this variable is applied.

An interesting observation from this study is that the exchange rate tended to be more under- than overvalued over the period studied (although to different degrees), with undervaluation episodes lasting longer than overvaluation periods. The longer periods of undervaluation could be explained

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[15] Other variables that were considered include the gold price, commodity price index, government debt to GDP ratio, foreign exchange reserves and the NEER but these were found to be insignificant. These variables were identified based on the empirical literature.

by the lack of adequate foreign exchange reserves that would have allowed the SARB to intervene in the foreign exchange market in earlier years, or the non-intervention policy adopted by the central bank after 1999. A closer look at the trade figures over the sample period indicates that South Africa's imports have been growing faster than exports (Table 2.1) thus feeding into the current account deficit problem. On the one hand, such developments should have been expected to be inflationary, but inflation on average came down over this period mainly due to a successful inflation targeting monetary policy framework by the SARB. The challenge for the SARB is the ability to deal with abrupt exchange rate misalignment episodes that are accompanied by high levels of nominal exchange rate volatility. With an undervalued currency seen as supportive for growth through higher exports (Rodrik, 2008a), the question is why the country has failed to take advantage of such misalignment episodes. A closer look at the results (Figures 2.3 and 2.4) indicates that most exchange rate undervaluation episodes have mainly been in response to either idiosyncratic shocks emanating from internal economic challenges (e.g. the rand crisis of 2001) or systemic global factors (2007/2008 global financial crisis) that are transmitted either through the nominal exchange rate or capital flows (second key finding of the study). These undervaluations have tended to be abrupt and at times extreme with a quick correction and sharp movement to overvaluation such that it cannot be possible for economic agents to make informed decisions based on such exchange rate behaviour. Structural weaknesses in the economy, like the lack of appropriate infrastructure and inflexible labour, could also cause the country to be unable to take advantage of weaknesses in the currency. For an undervalued exchange rate to have a macroeconomic impact on exports and economic growth, such misalignment has to be policy-induced such that the extreme movements are avoided, which has not been the case in South Africa. On the same note, one can also observe that exchange rate overvaluation episodes have coincided with good economic performance (e.g. between 2003 and 2006). When the economy is performing well, there is sufficient scope for the central bank to initiate policy that will have the effect of weakening the exchange rate in an effort to support long-term export performance. However, such a policy would need to be applied consistently over time for the desired effects to be realised.

From a policy perspective, besides the exchange rate, policymakers have to look at other factors in an effort to boost export performance since exchange rate policy on its own would not yield the desired results. Rodrik (2008b) notes that South Africa's unsatisfactory growth and employment path realised since the democratic transition is a function of an underperforming, non-resources tradable sector, in particular manufacturing. With the country's unemployment rate very high (especially amongst unskilled labour), having more flexible labour laws where wages are linked to productivity could be one way of boosting the manufacturing sector and hence more exports. There is a need for government, organised labour (unions) and the private sector to work together to find sustainable solutions to these challenges. An undervalued exchange rate that is accompanied by macroeconomic and political instability would also not yield any positive results since investor and business confidence is key in driving investment expenditure, exports and economic growth. It is hence crucial for the South African government to send a consistent and positive message on issues around macroeconomic policy that supports investment and economic growth.

In terms of further research, it would be interesting to formally ascertain the impact of such misalignment on economic indicators such as growth, exports and the current account deficit. Since the study merely sought to measure if the exchange rate was misaligned over time, another future area of research would be to determine the factors that drive such a misalignment within a regime switching context. In line with Goldfajn and Valdés (1999), an investigation into the factors that drive the reversion of the exchange rate back to equilibrium (nominal exchange rates or inflation differentials) in South Africa is also an area worth exploring.

Given that exchange rate volatility represents another dimension of exchange rate uncertainty, the next chapter applies GARCH methodologies to model the behaviour of the REER of the South African rand.

CHAPTER 3:
MODELLING REAL EFFECTIVE EXCHANGE RATE VOLATILITY: EVIDENCE FROM SOUTH AFRICA

3.1 INTRODUCTION

Exchange rate volatility is quite a topical issue in South Africa, especially its potential pass-through to economic factors that include trade, investment, inflation, employment and – ultimately – economic performance. Volatility, ordinarily defined as the standard deviation or variance in the returns of a financial asset during a given time period, is widely used to quantify risk such that it is a key input in investment decisions. According to the Bank for International Settlements (BIS) Central Bank triennial survey (2013), the South African rand is one of the most traded currencies globally, with the survey placing the rand at number 18 out of a total of 35 currencies in terms of the currency distribution of global foreign exchange market turnover. Amongst its emerging market peers, the rand is ranked as one of the most volatile currencies owing to the close integration of South Africa to the world economy and its liquid and well-developed foreign exchange market. South Africa therefore experiences booms and busts in step with global capital flows and in response to global macroeconomic and financial market developments (see e.g. Ngandu, 2008; Aye *et al.*, 2015; Hassan 2015; Mpofu, 2016).

Given that a volatile exchange rate is prone to bounds of appreciation and subsequent depreciation, it raises challenges for policymakers, investors and companies engaged in international trade as investment decisions become difficult to make, thus leading to the possibility of undermined economic performance. For example, risk-averse exporters faced with unexpected movements in exchange rates would reduce their level of output as this uncertainty directly translates into a profit risk (Choudhry & Hassan, 2015). Assuming most exporters are risk-averse, a country faced with high exchange rate volatility could see reduced export volumes and investment and hence slower economic performance. Eichengreen (2007) states that at a broader macroeconomic level, avoiding excessive exchange rate volatility ensures that a country is able to exploit its capacity for growth and development. This could be attributed to (1) the observed slowing of global growth experienced after the breakdown of exchange rate stability both in the 1930s and 1970s, and (2) country-specific episodes of growth declines that have coincided with high levels of exchange rate volatility.

In a different context, Akgul and Sayyan (2008) state that for emerging market countries, episodes of high exchange rate volatility move together with inflation volatility, whilst studies that include Crowley and Lee (2003) and Diallo (2008) indicate that exchange rate volatility impedes investment. Another strand in the literature (e.g. Frenkel & Ross, 2006; Demir, 2010) show that foreign exchange rate volatility reduces employment in developing countries. Takaendesa *et al.* (2006), however, note that at both the theoretical and empirical levels, the influence of exchange rate volatility on trade flows (and other macroeconomic factors) is inconclusive, thus making continued research in the area a worthy pursuit. One of the reasons behind the conflicting results is the choice of exchange rate volatility measure, since different studies apply different measures of volatility.

It is well noted by Serenis and Tsounis (2014) that one of the key considerations to be made in modelling the relationship between exchange rate volatility and economic factors is the choice or measure of volatility to be applied in the empirical study. Since exchange rate volatility is not directly observable, there is no undisputed correct or incorrect way to model it. An identification of the most suitable volatility gauge is therefore essential in order to accurately capture the effects of exchange rate volatility on macroeconomic factors such as trade, investment, employment and growth. As stated by Aye *et al.* (2015), the ability to accurately model and forecast exchange rate volatility facilitates better decision and policy making through eliminating future uncertainties. Besides influencing macroeconomic activities, foreign exchange rate volatility has applications in option pricing, risk management (e.g. value at risk estimates), portfolio selection and volatility-based trading strategies such that good forecasts for volatility are applicable in such contexts as well.

Although the subject of volatility has been widely researched, the global financial crisis experienced in 2007-2008 and the subsequent regulations aimed at appropriate risk management in the financial sector have reintroduced the need for more appropriate approaches to the estimation of the risk associated with financial asset prices such as exchange rates. The objective is to find a risk measure that accurately captures the volatility characteristics of financial variables. In the South African literature, several studies (e.g. Aye *et al.*, 2015; Sekantsi, 2011; Todani & Munyama, 2005) have assessed the macroeconomic effects of exchange rate volatility by using different measures of volatility. Such studies have mainly paid attention to the impact of exchange rate volatility without necessarily exploring which measure of volatility correctly captures the characteristics of the rand such that it could produce better volatility forecasts going forward. Given that the literature is not unanimous as to which measure is most appropriate, the main objective of this essay is to investigate the volatility characteristics of the rand's REER by considering the performance of various GARCH specifications.

This essay therefore seeks to extend the literature by identifying a model that produces a better exchange rate volatility measure of the rand such that it could be applied in empirical studies, volatility forecasting or risk management. The study compares the fitting and forecasting abilities of the symmetric autoregressive conditional heteroscedasticity (ARCH) and GARCH (1,1) models against two asymmetric models: the GJR-GARCH (1,1) named after Glosten, Jaganathan and Runkle (1993) and the exponential GARCH (EGARCH) (1,1) models. The objective is to explore the relevance and compare the performance of the models in terms of capturing the stylised facts about the volatility features of the REER and thus identify the best model for applied volatility modelling and forecasting. These models are chosen for their widely demonstrated ability to model and forecast the volatility of financial asset prices (Brownlees, Engle and Kelly, 2011). Brooks (2008) states that the GARCH (1,1) model owes its popularity and wide usage to the fact that it is parsimonious.

The rest of this essay is structured as follows: Section 3.2 provides a literature survey on the topic. Section 3.3 presents the GARCH models applied in the study. Section 3.4 describes the dataset used in the analysis and Section 3.5 discusses the empirical results and provides a conclusion.

3.2 LITERATURE

Well noted in the literature is the fact that financial time series variables such as exchange rates exhibit certain ‘stylised facts’ that cannot be adequately explained by linear models (see Enders, 2010; Brooks, 2008). Such characteristics include volatility clustering and persistence, fat tails, leverage effects, long memory, co-movement in volatility and the effects of regular events such as holidays or weekends. The suite of GARCH models has gained popularity in recent years given their observed ability to capture the volatility characteristics of time series data. A number of empirical studies therefore compare the ability of various GARCH specifications to model the volatility behaviour of financial variables such as exchange rates, stock prices, oil prices and bond yields, with the studies yielding mixed results. The main objective of such studies is to identify optimal methods that can accurately model and forecast the conditional variance of such financial time series for application to risk management, investment strategies or the pricing of financial derivatives (options). Since the literature on the topic is abundant, the selected studies below are not exhaustive but simply highlight some of the pertinent conclusions arise from such studies. The studies chosen are those that specifically compare the ability of GARCH type specifications to model financial time series variables like stock prices and exchange rates.

Papers that have applied GARCH methods to model stock returns include Gokcan (2000), who compares the ability of a linear GARCH model against the nonlinear EGARCH model to explain the volatility behaviour of stock market returns in seven emerging market nations. Using data from 1988 to 1996, the study confirms that even if returns are significantly skewed, the linear GARCH model is still adequate in modelling the volatility of time series as it produced better results than the nonlinear EGARCH model. Dima, Haim and Rami (2008) compare the performance of several GARCH models with different error distributions applied to two Israeli (Tel Aviv) stock indices. Their results show that the EGARCH model with skewed Student-t distribution outperformed the GARCH, GJR-GARCH and APARCH models such that the authors conclude it could be more applicable for risk management strategies associated with the Tel Aviv stock market. Using daily data from the Indian stock market, Karunanithy and Ramachandran (2015) apply a combination of symmetric and asymmetric GARCH models: (GARCH (1,1); GARCH-M (1,1); EGARCH (1,1) and TGARCH (1,1) models) to estimate the volatility of the Indian Nifty stock index. Their results indicate that the TGARCH model was the best suited due to its ability to correctly capture asymmetric effects in the volatility of the index returns. This study applies the AIC and SIC to identify the best fitting model among the different specifications. Other researchers that have investigated the ability of GARCH models to explain volatility of stock market returns include Srinivasan (2011) for the S&P 500; McMillan, Speight and Gwilym (2000) for the UK FTA All Share and FTSE100 stock indices; Yu (2000) for the New Zealand stock market and Wei (2002) on Chinese stock market volatility. Besides stock prices, other authors have used the GARCH family of models to explore and forecast the volatility of other financial indicators, e.g. Chkili, Hammoudeh and Nguyen (2014) for widely traded commodities including gold, crude oil, natural gas and silver; Tian and Hamori (2015) for short-term interest rates; and Manzoni (2002) on Eurobond bond market credit spreads.

On the literature specific to exchange rate modelling, earlier studies such as Pagan and Schwert (1990), and Cao and Tsay (1992) evaluate the modelling capabilities of various models and find that the EGARCH model has better predictive capabilities than the linear GARCH model due to its ability to capture leverage effects. Balaban (2004) compares the out-of-sample forecasting accuracy of the symmetric (ARCH and GARCH) and asymmetric (GJR-GARCH and EGARCH) conditional variance models for the USD to Deutsche mark (DEM) exchange rate volatility using daily data from 1974 to 1997. Using statistics that include the mean error (ME), mean absolute error (MAE), mean squared error (MSE) and mean absolute percentage error (MAPE) to evaluate forecasting performance, Balaban (2004) concludes that whilst the standard symmetric GARCH model provides relatively good forecasts of monthly exchange rate volatility, the EGARCH model was the best performer in terms of volatility forecasting. Henry and Summers (1999) model volatility of the real Australian dollar exchange rate and conclude that the random walk model can be improved by employing GARCH specifications including the GARCH (1,1) and GARCH-M models. Other early studies that confirm the superiority of nonlinear GARCH models to model and forecast exchange rate volatility include West and Cho (1995) who applied weekly data for the US dollar and Vilasosu (2002) who also uses daily exchange rate data for the US dollar against other major currencies.

Amongst the more recent studies, Pilbeam and Langeland (2015) use daily prices to compare the forecasting performance of several specifications of univariate GARCH models with implied volatility forecasts derived from currency options for four exchange rate pairs (USD/JPY, USD/CHF, EUR/USD and GBP/USD). Motivated by the need to examine the efficiency of the foreign exchange market in pricing option volatility, their study finds that the three GARCH models applied (GARCH (1,1); EGARCH (1,1); and GJR-GARCH (1,1)) fail to outperform the implied volatility forecasts in periods of both low and high volatility based on the root mean squared error criterion. Pilbeam and Langeland (2015) use the root mean square deviation (RMSE) as a measure of forecast accuracy. Akgul and Sayyan (2008) studied the relative success of stable (GARCH, GJR-GARCH, PARCH, EGARCH), integrated (IGARCH) and long-memory (FIGARCH, HYGARCH, FIEGARCH and FIAGARCH) models in forecasting the volatility of bilateral Turkish lira exchange rates against several currencies (USD, EUR, CAD, AUD, GBP and JPY) over two periods (1990-2005 and 2001-2005). Their results show that in the first sub-period, the long-memory model specifications accurately captured the volatility dynamics of the Turkish lira against the USD and CAD, whilst the stable GARCH correctly explained the volatility of the AUD, JPY, EUR and GBP. Only the stable model specifications were relevant in the sub-period (2001-2005) as the series no longer had long-memory features. The authors used various statistics to assess the forecasting ability of the various methods including the mean squared error (MSE), MAE and the Theil inequality coefficient (TIC).

Antonakakis and Darby (2013) explore whether the modelling and forecasting power of volatility models that have been successful in developed countries could perform equally well when used in developing countries. Using daily exchange rate series, their study confirms that the FIGARCH was the best performing model for industrialised countries over all forecasting horizons as it captured the volatility properties for the chosen countries. For developing countries, compared to other models that include the ARCH, GARCH, FIGARCH, HYGARCH and EGARCH, the authors found that the IGARCH fitted the data well and the presence of structural breaks rather than long-memory could be responsible for the outcome. Chipili (2012) modelled volatility of the real exchange rate of the Zambian kwacha against eight currencies employing three specifications: the GARCH (1,1), TGARCH (1,1) and EGARCH (1,1). The author emphasises the importance of employing alternative GARCH models in examining conditional volatility since imposing a uniform method is deemed inappropriate. Abdalla (2012) applies data from 19 Arab countries to confirm that exchange rate volatility in those countries can be correctly modelled by using the GARCH (1,1) and EGARCH (1,1) models, with the latter model being preferred due to its ability to provide evidence of leverage effects on most of the currencies studied. Brownlees *et al.* (2011) undertake a comparative study within the GARCH suite of models to assess the performance of these models across different asset classes and volatility regimes. Their results indicate that the GJR-GARCH model of Glosten *et al.* (1993) produces the best volatility forecasts across asset classes and subsamples when compared to the GARCH (1,1), EGARCH, NGARCH and APARCH models.

An early study that focuses on modelling volatility of stock returns in South Africa is by Samouilhan and Shannon (2008) who used daily data from 2004 to 2006 to compare volatility forecasts from ARCH/GARCH models, the implied volatility index (Safex Interbank Volatility Index (SAVI)) and measures based on historical volatility. Babikir, Gupta, Mwabutwa and Owusu-Sekyere (2012) note that despite the extensive literature on forecasting volatility of financial asset returns, there is limited empirical work that pays specific attention to South Africa. The authors use the GARCH methodology to model the volatility of stock returns in South Africa in the presence of structural breaks, noting that failure to account for such structural breaks in the unconditional variance could lead to bias and inaccurate volatility forecasts. Using daily data of the JSE All-Share index from 1995 to 2010, their study concludes that the GARCH (1,1) method seems to provide better in-sample and out-of-sample forecasts for stock-return volatility even in the presence of structural breaks, and performed better compared to the asymmetric GJR-GARCH (1,1) and the MS-GARCH (1,1) models. The authors conclude that the TGARCH (2,2) model specification provided the best forecasts for stock market volatility. Other studies that have assessed the ability of various GARCH specifications to model and forecast stock market volatility in South Africa include Makhwiting, Lesaoana and Sigauke (2012) and Niyitegeka and Tewari (2013).

Aye, Balcilar, Bosch, Gupta and Stofberg (2013) analysed the out-of-sample forecasting power of nonlinear Band-Threshold Autoregressive (Band-TAR) and Exponential Smooth-Transition Autoregressive (ESTAR) models compared to linear autoregressive models for the rand's exchange rate against both the US dollar and Great British pound. Their study was motivated by their observation that most studies in the South African literature on forecasting the exchange rate are based on explaining the exchange rate as a function of fundamentals such as commodity prices, capital flows and the like (e.g. MacDonald & Ricci, 2004; Mtonga, 2006). Applying monthly data from 1970 to 2012, Aye *et al.* (2013) conclude that both nonlinear models (Band-TAR and ESTAR) did not provide any significant improvement in forecasting the exchange rate, especially over short time horizons, compared to the linear auto regressive model. Several other studies in the South African literature apply different GARCH methods to assess the impact of exchange rate volatility on economic factors (e.g. Farrell (2001); Bah & Amusa (2003); Mpofu (2016)), but do not justify their choice of GARCH method. This study seeks to enrich the literature by trying to compare the performance of various GARCH specifications to model and forecast volatility of the South African rand – a subject that has been largely ignored so far.

3.3 VOLATILITY MODELLING AND GARCH MODELS

GARCH models can be broadly classified into two main categories (Akgul & Sayyan, 2008): symmetric (linear) and asymmetric models. The first class of models (including the traditional GARCH 1,1 model) explains the conditional variance as a function of a long-term mean of the variance, its own lags and the previous realised variance (Abdalla & Winker, 2012). The main shortcoming of linear models is their inability to capture the asymmetric or leverage effect of volatility whereby negative shocks cause higher volatility than positive shocks of a similar magnitude. Asymmetric GARCH models (e.g. EGARCH, GJR and APARCH) improve on volatility forecasts though their ability to capture such leverage effects.

Using the family of GARCH models, the conditional variance of the exchange rate will be estimated and modelled in this study[16]. Since the literature on volatility modelling using GARCH models is extensive, for compactness this study considers three popular models: one symmetric model (GARCH (1,1)) and two asymmetric specifications (EGARCH (1,1) and GJR-GARCH (1,1)). A random walk model is used for the exchange rate (i.e. random walk with drift) as the initial regression for the conditional mean and then the null hypothesis that there are no ARCH effects in the series is tested[17]. The conditional variance is then estimated using the GARCH models. Brooks (2008) states that under ARCH models, the autocorrelation in volatility is modelled by allowing the conditional

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[16] Although the focus of the study is on the application of the popular GARCH models, other simpler methods of measuring volatility based on past conditional variance include the random walk model, historical mean, simple moving average, exponential smoothing and the exponentially weighted moving average.
[17] The random walk model of the exchange rate is chosen due to its popularity in explaining the behaviour of exchange rates (see e.g. Almudhaf, 2014).

variance of the error term to depend on the immediate previous value of the error term. Such a model thus makes it possible to capture the well-noted stylised facts of financial time series that include volatility clustering and leverage effects. Conversely, in GARCH models, the variance structure of residuals derived from the exchange rate conditional mean equation are modelled to capture the extent to which the exchange rate moves around to reproduce the characteristic features of the exchange rate series.

a) *GARCH (1,1)*

Engle (1982) is credited with proposing the ARCH model which estimates the variance of returns as a function of lagged values of the squared error term. Assuming a random walk model of the exchange rate as follows (random walk with drift is used for the mean equation):

$$Y_t = \beta_1 + \beta_2 Y_{t-1} + \varepsilon_t \text{ where } \varepsilon_t = \sigma_t u_t \qquad \ldots(3.1)$$

The conditional variance of the model therefore depends on *q* lags of the squared error term as follows:

$$\sigma^2 = \alpha_0 + \sum_{l=1}^{q} \alpha_i u^2_{t-1} \qquad \ldots(3.2)$$

Given the various limitations associated with the ARCH model[18], Bollerslev (1986) and Taylor (1986) extended the ARCH model and developed the widely popular GARCH (*p,q*) specification which allows the conditional variance to depend on *q* lags of the squared error term and *p* lags of the conditional variance:

$$\sigma^2 = \alpha_0 + \sum_{l=1}^{q} \alpha u_i{}^2_{t-i} + \sum_{j=1}^{p} \beta\sigma^2_{t-j} \qquad \ldots(3.3)$$

The most popular model in the literature is the GARCH (1,1) whereby the conditional variance (σ^2) is a one-period-ahead estimate for the variance calculated as a function of past information (Pilbeam & Langeland, 2015) expressed as:

$$\sigma^2 = \alpha_0 + \alpha_1 u^2_{t-1} + \beta_1 \sigma^2_{t-1} \qquad \ldots(3.4)$$

The GARCH (1,1) model is therefore a function of three terms: the mean (α_0), the ARCH term (u^2_{t-1}) and the GARCH term (σ^2_{t-1}) where the coefficients α_1 and β_1 are assumed to be positive to ensure that the conditional variance (σ^2) is always positive; and $\alpha_1+\beta_1<1$ to ensure stationarity of the process is achieved (Dima *et al.*, 2008). While it has been well noted (e.g. Karunanithy & Ramachandran, 2015; Epaphra, 2017) that the ARCH and GARCH models can correctly capture the volatility clustering and leptokurtosis effects of time series data, since they are symmetric they fail to capture the leverage effects of volatility (i.e. the fact that volatility is higher after negative shocks than after

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[18] These include how to determine the number of lags of the squared error required in the model and the possibility that the non-negativity constraint might be violated (Brooks, 2008).

positive shocks of the same magnitude). Stated differently, these models are symmetric in the sense that they do not take into account the possibility that 'bad news' has a tendency to increase volatility more than 'good news' (Nelson, 1991).

In order to address the issue of leverage effects, various extensions of the GARCH model have been proposed with the aim of capturing the possible asymmetries in volatility based on whether a shock was positive or negative. Two popular asymmetric models are considered in this study: the GJR-GARCH model (also termed the TGARCH or threshold GARCH model) and the Exponential GARCH model (EGARCH).

b) *The GJR-GARCH (1,1) model*

The GJR-GARCH model, attributed to Glosten *et al.* (1993), is an extension of the GARCH model with an additional term to capture potential asymmetry whereby a dummy variable is applied to allow the conditional variance to respond differently to past negative and positive innovations (Brooks, 2008). The conditional variance in this model is expressed as:

$$\sigma^2 = \alpha_0 + \alpha_1 u^2_{t-1} + \beta_1 \sigma^2_{t-1} + \gamma u^2_{t-1} I_{t-1} \quad \text{...(3.5)}$$

where I_{t-1} is a dummy variable such that:

I_{t-1} = 1 if $u_{t-1} < 0$ (bad news)
= 0 otherwise (good news) …(3.6)

The dummy variable therefore allows for the verification of whether there is a statistically significant difference between positive and negative shocks. In the GJR model, leverage effects are confirmed if $\gamma > 0$ such that if $\gamma = 0$, the conclusion is that news effects are symmetric. The non-negativity constraint in this model requires that $\alpha_0 > 0$; $\alpha_1 > 0$; $\beta \geq 0$ and $\alpha_1 + \gamma \geq 0$.

c) *The EGARCH (1,1) model*

Another extension to the GARCH model that caters for asymmetry is the EGARCH model advanced by Nelson (1991). In the EGARCH model, the specification for the conditional variance can be expressed as follows (Enders, 2010):

$$\ln(\sigma^2) = \alpha_0 + \alpha_1 (u_{t-1} / \sigma_{t-1}^{0.5}) + \lambda_1 |u_{t-1} / \sigma_{t-1}^{0.5}| + \beta_1 \ln(\sigma^2_{t-1}) \quad \text{...(3.7)}$$

where the conditional variance ($\ln(\sigma^2)$) is in log-linear form. The EGARCH model introduces a form of asymmetry dependent not only on the positive or negative sign of innovation, but also on the magnitude of this shock. Such a model expresses the conditional variance as a nonlinear function of its own past values that can react asymmetrically to good and bad news (Drimbetas, Sariannidis & Porfiris, 2007). When $u_{t-1}/\sigma_{t-1}^{0.5}$ is positive, the effect of a shock on the variance is $\alpha_1 + \lambda_1$; antithetically, if $u_{t-1}/ \sigma_{t-1}^{0.5}$ is negative, the effect of the shock on the conditional variance is $-\alpha_1 + \lambda_1$, thus allowing for asymmetry (Enders, 2010).

3.4 DATA

The study specifically considers the REER of the South African rand with monthly data from 1980 to 2016 applied (sourced from the South African Reserve Bank). Figure 3.1 plots the time series for the rand's REER, with the chart indicating swings in the exchange rate covering interactions between appreciation and depreciation episodes. For example, following a decline in the REER index between 2007 and 2008 (i.e. during the global financial crisis), the exchange rate appreciated from 2009 to 2010 only to depreciate once again from 2011 to 2015. Such variations in exchange rate movements should normally be expected to be accompanied by high levels of volatility, as has been the case with the rand.

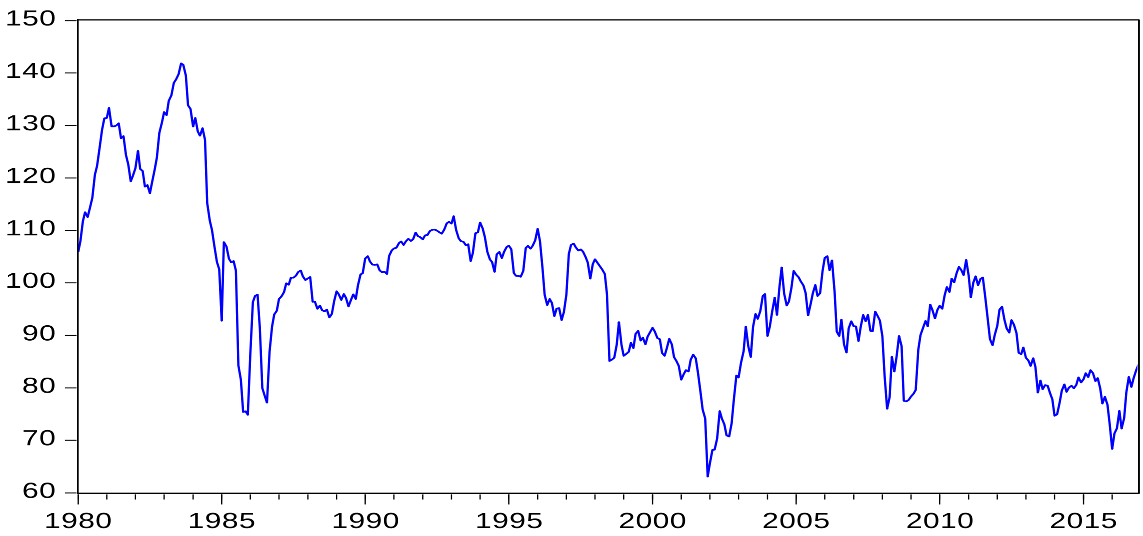

Figure 3.1: Real effective exchange rate

Data source: South African Reserve Bank

In line with the literature on volatility modelling (see for example Antonakakis & Darby, 2013; Narayan, Narayan and Prasad, 2009), the author focuses on the changes in the exchange rate (i.e. monthly returns of REER) calculated as the first difference in the log of the REER as follows:

$$RetREER_t = log\left(\frac{REERt}{REER(t-1)}\right) \quad ...(3.8)$$

where $RetREER_t$ is the monthly percentage return to the exchange rate, $REER_t$ and $REER_{t-1}$ denoting the exchange rate at time *t* and *t-1* respectively.

Table 3.1: Summary descriptive statistics for RetREER

Variable	Mean	Max	Min	SD	Skewness	Kurtosis	Jarque-Bera
RETREER	-0.0005	0.1494	-0.1941	0.0330	-0.6909	10.0183	944.427

Table 3.1 presents the summary statistics for the returns data indicating that the mean return is close to zero with skewness and excess kurtosis clearly observable. The Jarque-Bera statistic rejects the null hypothesis of a normal distribution at the 1% confidence level (p value of 0.000). In summary, it may be concluded that the return series does not conform to a normal distribution with a negative skew (a normally distributed series is expected to have skewness of 0 and kurtosis of around 3). This implies that exchange rate movements in either direction (appreciation or depreciation) could occur more frequently than would be in a normally distributed setting (Bala & Asemota, 2013). The negative skewness implies that the lower tail of the data distribution is thicker than the upper tail, with exchange rate depreciations more prevalent than appreciations over the sample period.

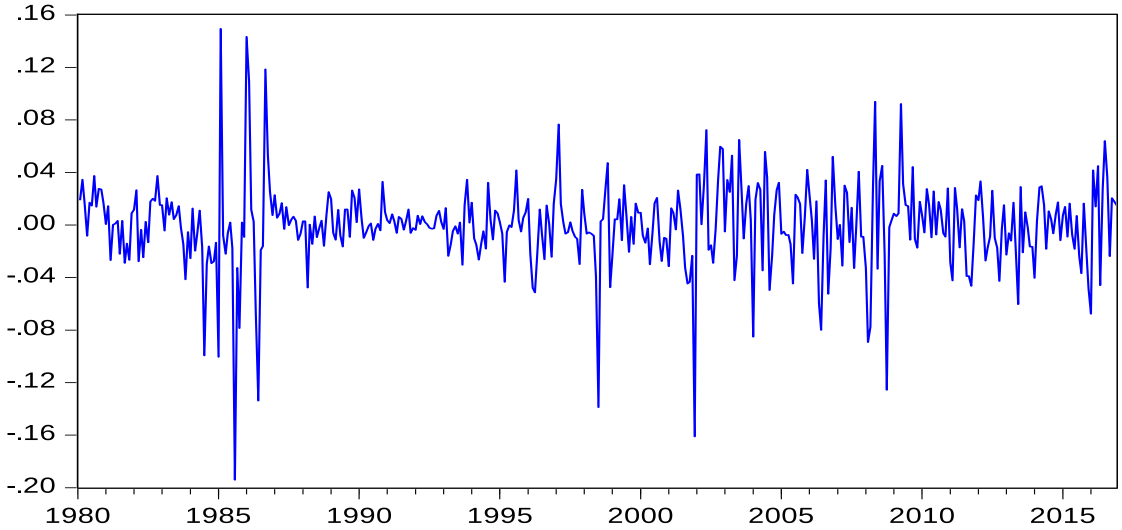

Figure 3.2: Changes in the REER (in logarithms)

Note: Author's own calculations based on SARB data

A visual inspection of the return series (Figure 3.2) suggests the presence of the characteristics common with financial time series data (i.e. volatility clustering associated with ARCH processes, and a time-varying variance). For example, there appears to be high volatility in the year 1985; where after a period of relative tranquillity is observable between 1986 and 1994; volatility in returns increased after 1995, with the level of volatility high during the financial crisis between 2007 and 2009. The statistical properties of the exchange rate series thus render the suite of ARCH/GARCH models appropriate since they are known to capture the stylised facts of financial time series.

Before applying the GARCH models, we formally test for the presence of unit root and evidence of heteroscedasticity in the series as a necessary precondition (results presented in Table 3.2 below). Using the Augmented Dickey-Fuller and Break-point unit root tests, the null hypothesis of unit root in the exchange rate series was rejected (no need to difference the series). The ARCH-LM test for heteroscedasticity indicates the existence of ARCH effects as the null hypothesis of no ARCH effects was also rejected, confirming that the variance of the error terms is not constant over the sample period[19]. Such properties of the exchange rate return series support the usage of GARCH models in modelling the volatility given the time-varying variance.

Table 3.2: Unit root and ARCH test results for RetREER

	ADF		Break-Point	
	Intercept	Trend and Intercept	Intercept	Trend and intercept
Level	17.27***	17.25***	-18.09***	-18.08***
Test for ARCH Effects				
ARCH LM (1) Test: F-statistic			5.7400**	

Note: Author's estimation

3.5 EMPIRICAL RESULTS

The estimates of the univariate GARCH models are presented in Tables 3.3-3.5 below. The in-sample performance is measured on the basis of how each model fits the data over the sample period using the AIC and SIC, stationarity in the conditional variance and satisfaction of the non-negativity constraint. The performance of the three models is compared under three error distribution processes: the normal distribution, the Student's t-distribution and generalised error distribution (GED) as presented in the respective tables. The model with the lowest AIC and SIC statistics whilst satisfying the conditional variance stationarity and non-negativity constraints is regarded as the best in-sample model. For diagnostic tests of the models, the ARCH LM test is reported in order to ascertain if there are any remaining ARCH effects once each volatility model has been estimated.

Table 3.3 reports the results from the three models (GARCH 1,1), GJR-GARCH (1,1) and EGARCH (1,1) models assuming a normal error distribution. The results reveal that the ARCH coefficient (α_1) is statistically significant in all the model specifications except the GJR model, thus confirming the presence of volatility clustering in the real exchange rate series of the rand. The significant GARCH (β_1) coefficient in all three models indicates that news about volatility in the previous period explains current volatility. In the GARCH (1,1), both ARCH and GARCH coefficients are positive and statistically significant, but the sum of the coefficients ($\alpha_1 + \beta_1$) is greater than 1 (1.0267), suggesting that the conditional variance is an explosive process (shocks to the exchange rate are high and persistent such that they remain over a considerable period of time). The result shows that there is nonstationarity in the conditional variance from this model: the GARCH (1,1) model therefore does not satisfy the covariance stationarity condition ($\alpha_1 + \beta_1 < 1$). The ARCH LM test shows that no ARCH

[19] The ARCH test was performed on the random walk model with a lag of 1. The study, however, fails to reject the null hypothesis of no ARCH effects at 3 lags.

effects remain after estimation of the GARCH (1,1) model. The explosive conditional variance observed, however, renders this model unsuitable for modelling the volatility of the rand.

Table 3.3: Parameter estimates (normal distribution)

Parameter	GARCH (1,1)	GJR-GARCH (1,1)	EGARCH (1,1)
Mean equation			
c	0.0012	-0.0007	-0.0008
RetREER(-1))	0.2095***	0.2628***	0.2283***
Variance equation			
α_0 (Constant)	3.25E-05***	3.52E-05***	-0.5677***
α_1 (ARCH effect)	0.2812***	0.0122	0.2318***
β_1 (GARCH effect)	0.7455***	0.7591***	0.9459***
γ (Leverage effect)		0.4838***	-0.2455***
$\alpha_1 + \beta_1$ (stationarity)	1.0267	0.7714	1.1777
Test for ARCH effects			
Before GARCH model			
ARCH LM(1) test	5.7000	5.7000	5.7000
Probability	0.0170	0.0170	0.0170
After GARCH model			
ARCH LM(1) test	0.2324	0.0057	0.0038
Probability	0.6300	0.9398	0.9507
Forecast evaluation			
RMSE	0.0324	0.0325	0.0324
MAE	0.0210	0.0211	0.0210
TIC	0.8098	0.7769	0.7972

*, **, *** means statistically significant at 10%,5% and 1% respectively.
RMSE is the root mean squared error, MAE the absolute mean error and TIC the Theil Inequality Coefficient.

Regarding the asymmetric models, in the GJR-GARCH (1,1) model the coefficient for asymmetry (*γ*) is positive and highly statistically significant (at 1%), confirming the leverage effects. In other words, ‘bad news’ has a higher impact on volatility than good news, meaning that exchange rate volatility increases faster during REER depreciation episodes (undervaluation as well) as compared to exchange rate appreciation (also overvaluation) episodes of similar magnitude. The GARCH coefficient is statistically significant (at 1%) with the ARCH coefficient positive but not significant, implying that the GARCH effect dominates the ARCH effect in explaining the conditional variance in this model. The sum of the coefficients $\alpha_1 + \beta_1$ is less than 1 (0.7714), confirming stationarity in the conditional variance process. The ARCH LM test shows that no ARCH effects remain after estimation of the GJR-GARCH (1,1) model. Such results render the GJR-GARCH a suitable model for rand volatility.

Results from the EGARCH (1,1) model indicate all the estimated coefficients statistically significant (at 1%). The leverage effect indicator is negative according to expectations and also highly significant at 1%, also confirming that negative shocks to volatility imply a higher next period conditional variance than positive shocks of the same magnitude. The ARCH LM test shows that no ARCH effects remain after estimation of the EGARCH (1,1) model. The model is, however, rejected because it suffers from a key problem: the sum of the ARCH and GARCH coefficients ($\alpha_1 + \beta_1$) is greater than 1 and very high at 1.1777, which suggests that the conditional variance is an explosive process. The result shows that there is nonstationarity in the conditional variance from this model such that the EGARCH (1,1) model fails the covariance stationarity condition ($\alpha_1 + \beta_1 < 1$).

Based on the observations above, the GJR-GARCH (1,1) model is selected as the most appropriate to estimate the rand's volatility given the statistically significant coefficients (GARCH and leverage effect coefficients), a stationary conditional variance process ($\alpha_1 + \beta_1 < 1$), satisfaction of the non-negativity constraints and the fact that this model eliminates ARCH effects. The GARCH (1,1) and EGARCH (1,1) models fail to satisfy all of the conditions indicated above and are hence deemed inadequate. In order to confirm the above results, the three models (GARCH, GJR-GARCH and EGARCH) were also estimated assuming two other error distributions (Student's t and the generalised error distributions), with neither of these models performing better than the GJR-GARCH (1,1) model above. All the models either failed the non-negativity constraint or the stationarity condition (see Tables 3.4 and 3.5 for a summary). Estimates of GARCH-in-mean models also did not produce better results than the GJR-GARCH (1,1) with a normal distribution. To complete the analysis, the out-of-sample forecasting power of the three models was evaluated using three commonly used error statistics: the RMSE, MAE and TIC. These statistics represent forecast errors in terms of how far the forecast is relative to the actual data such that the model with the smallest statistics is considered the one with the most accurate forecasts (Brooks, 2008). As can be seen from Table 3.3 above, the GJR-GARCH (1,1) can still be considered the best model for out-of-sample forecasting based on the lowest RMSE, MAE and TIC statistics[20].

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[20] A forecast horizon of two years was applied for the out-of-sample forecasts.

Table 3.4: Parameter estimates (Student's-t distribution)

Parameter	ARCH	GARCH (1,1)	GJR-GARCH (1,1)	EGARCH (1,1)
Mean equation				
c	0.0006	0.0007	0.0002	-5.71E-05
RetREER(-1))	0.1866***	0.1787***	0.2208***	0.2054***
Variance equation				
α_0 (Constant)	0.0007***	4.02E-05**	3.71E-05***	-0.5461***
α_1 (ARCH Effect)	0.6566**	0.2559***	-0.0219	0.2550***
β_1 (GARCH Effect)		0.7551***	0.7932***	0.9518***
γ (Leverage Effect)			0.4132***	-0.2108***
$\alpha_1 + \beta_1$		1.0110	0.7713	1.2068
ARCH LM(1) Test	0.2693	0.2795	0.0067	0.0025
Probability	0.6041	0.5972	0.9346	0.9596

*,**,*** means statistically significant at 10%,5% and 1% respectively.

Table 3.5: Parameter estimates (GED)

Parameter	ARCH	GARCH (1,1)	GJR-GARCH (1,1)	EGARCH (1,1)
Mean equation				
c	0.0010	0.0007	0.0001	-2.31E-05
RetREER(-1))	0.1737***	0.1847***	0.2188***	0.2101***
Variance equation				
α_0 (Constant)	0.0006***	3.40E-05*	3.10E-05***	-0.5308***
α_1 (ARCH Effect)	0.5126**	0.2497***	-0.0003	0.2391***
β_1 (GARCH Effect)		0.7561***	0.7866***	0.9530***
γ (Leverage Effect)			0.4009***	-0.2177***
$\alpha_1 + \beta_1$		1.0058	0.7863	1.1921
ARCH LM(1) Test	0.2224	0.2474	0.0039	0.0047
Probability	0.6374	0.6008	0.9498	0.9450

*,**,*** means statistically significant at 10%,5% and 1% respectively.

Figure 3.3 below plots the volatility in the exchange rate as per the GJR-GARCH (1,1) specification. As can be observed from the graph, the model is able to capture the significant increases in exchange rate volatility experienced in South Africa since 1980, with such incidents of high volatility linked to the historical exchange rate depreciation episodes (sometimes termed currency crises). For example, the period around 1985 marks the highest level of volatility seen in the rand over the sample period. This was the time of heightened political uncertainty in South Africa and it was during this era when international financial institutions closed credit lines for South Africa, that there was a standstill in the country's international debt repayments and exchange controls for non-residents were introduced (Mboweni, 2001). Some calmness was restored to the foreign exchange market in the build-up to the 1994 elections, with volatility increasing sharply shortly thereafter in 1997-1998 to coincide with the decline in the nominal exchange rate. Gidlow (2011) notes that after the successful democratic elections in 1994, South Africa started attracting global capital flows into the bond and equity markets and, following the East-Asian crisis, such capital flows into broad emerging markets were reversed, leading to high levels of exchange rate depreciation and currency volatility. This episode was accompanied by concerns around structural imbalances in the economy, including a weak current account position, low investment and a low level of the country's foreign exchange reserves.

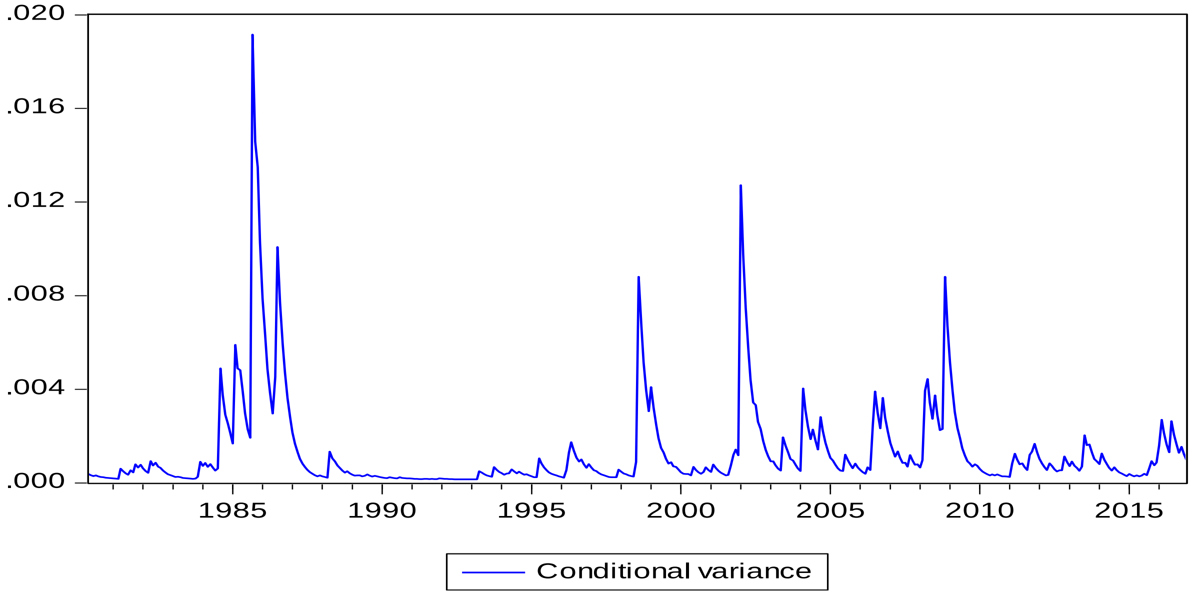

Figure 3.3: Volatility estimates from the GJR-GARCH (1,1) model

The year 2001 is associated with a significant depreciation in the exchange rate plus significant volatility thereof which was mainly associated with speculative attacks on the currency. This culminated in a commission of enquiry into the rapid depreciation of the rand over the period (Myburgh Commission of 2001), the report of which pointed to a number of factors including a slowdown in global economic activity, reduced capital flows to and risk aversion towards emerging markets, and the noninterventionist and exchange control policies of the SARB. The global financial crisis of 2007-2008 introduced the latest big spike in exchange rate volatility as this was accompanied by global recessionary conditions, declines in commodity prices and risk aversion strategies adopted against riskier emerging market assets. Other factors that have contributed to exchange rate volatility as seen in the latter years of the sample period include political factors associated with the reshuffling of the Ministry of Finance portfolio and speculation that South Africa would be downgraded below investment grade by the major global credit ratings agencies. In a nutshell, one can observe from Figure 3.3 that the GJR-GARCH (1,1) model has been able to capture the stresses in the foreign exchange market that have led to higher volatility. Finally, when one compares the exchange rate volatility estimates with the exchange rate undervaluation episodes identified in Chapter 2, occurrences of high exchange rate volatility as determined by the GJR-GARCH (1,1) model have historically coincided with high exchange rate undervaluation periods. Figure 3.4 below indicates that exchange rate volatility was quite high in 1985, 2001 and 2007: periods where there were extreme negative shocks to the currency leading to an undervaluation of the rand. This serves as confirmation of the existence of leverage effects in the rand's volatility, whereby volatility is higher during periods of exchange rate deprecation (or undervaluation as per this study) as compared to periods of overvaluation and plausibility of the GJR-GARCH (1,1) as an appropriate measure of the rand's volatility.

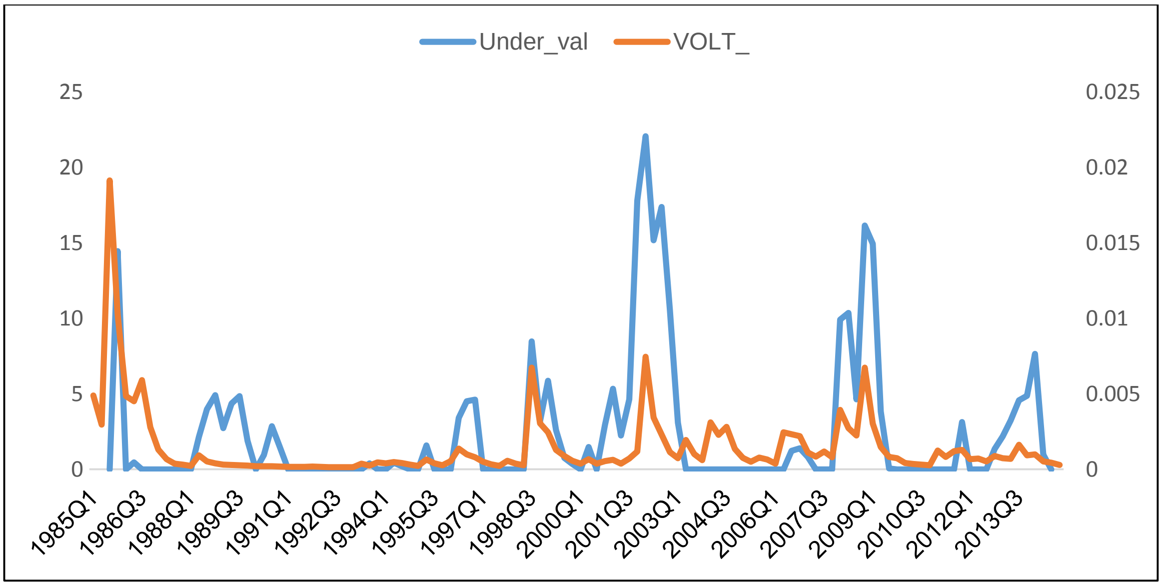

Figure 3.4: exchange rate volatility and undervaluation episodes

Source: Author's own calculations

3.6 CONCLUSION

The main findings from the study are that (1) the GARCH family of models can adequately capture the volatility dynamics of the South African rand, including volatility clustering and leverage effects; (2) both the GJR-GARCH and EGARCH models find evidence of leverage effects in exchange rate volatility such that negative shocks cause a higher level of volatility in the next period than a positive shock of the same magnitude; and (3) the GJR-GARCH (1,1) model with a normal error distribution is chosen as the best model for rand volatility since it satisfies all the necessary modelling criteria when compared to the other models. With exchange rate volatility, one of the challenges facing policymakers and investors in South Africa is the ability to accurately model and forecast the exchange rate behaviour of the rand. Based on the sample period and the data frequency chosen, the results from this study indicate that the GJR-GARCH (1,1) model is superior to the GARCH (1,1) and EGARCH (1,1) models such that it can be used to model the volatility of the rand's REER. Such a methodology can add value to the forecasting abilities of institutions such as the SARB, National

Treasury and investors with exposure to the exchange rate through either international trade or investments. From a policy perspective, since the study confirms that exchange rate undervaluation periods can be associated with high exchange rate volatility, it is important for the SARB to accumulate sufficient foreign exchange reserves that could be used to smooth exchange rate volatility in periods of excessive volatility. Although an undervalued exchange rate has the potential to promote growth and exports, the negative effects of volatility could crowd out the positive influence of undervaluation such that the ultimate impact on growth is not realised.

Although all GARCH model specifications used in the study indicate the ability to model the volatility of the rand's REER (with the GJR-GARCH (1,1) identified as the most superior model), one notable observation from the other models (GARCH (1,1) and EGARCH (1,1)) is the fact that the sum of the ARCH and GARCH coefficients ($\alpha_1 + \beta_1$) is greater than 1, an indication that volatility of the rand might be persistent or exhibit long-memory characteristics. Akgul and Sayyan (2008) state that the presence of long memory in certain time series data (e.g. exchange rates) might imply that volatility estimates captured by ordinary and stable GARCH type models could be unsatisfactory. One limitation of this study is that it has not explored the plausibility of either long memory or higher order ARCH/GARCH specifications. A worthy addition to the literature could therefore be modelling the rand's exchange rate using long memory models such as the Fractionally Integrated GARCH model (FIGARCH). A further possible limitation of this study is the fact that the exchange rate variable of interest (REER series) is only available on a monthly basis, whereas volatility modelling with ARCH/GARCH type methods produces the best results when applied to high-frequency data (daily or weekly series). The volatility estimates obtained in this study are further transformed into quarterly data for application in essays 3 and 4, and this has the potential to smooth the volatility with implications for the conclusions reached.

The next essay uses cointegration methods in an ARDL framework to study the impact of exchange rate misalignment and volatility on South Africa's economic performance. The misalignment and volatility measures constructed in the preceding two chapters are hence applied.

CHAPTER 4:
REAL EFFECTIVE EXCHANGE RATE MISALIGNMENT, VOLATILITY AND ECONOMIC PERFORMANCE IN SOUTH AFRICA

4.1 INTRODUCTION

The macroeconomic impact of exchange rate misalignment and volatility has been attracting increasing interest in recent years. This is mainly due to the persistent global macroeconomic imbalances and the purported role of some countries allegedly maintaining undervalued currencies to promote economic growth in their jurisdictions. As may be expected, policymakers and investors have a general preference for stable exchange rates since stability in this regard removes uncertainties and aids accurate future planning, thus contributing positively to economic growth. The economic impact of exchange rate misalignment (defined as the REER diverging from its equilibrium level) may be determined by investigating the direction and extent of such misalignment. A relatively undervalued currency can help promote development of the export sector, thus boosting investment, domestic production, income and employment (Gala, 2008). Rodrik (2008a) contends that exchange rate overvaluation has a negative impact on economic growth since it undermines exports, may lead to unsustainable current account deficits and introduces the possibility of a balance of payments crisis. As Berg and Miao (2010) observe, the real exchange rate remains an important factor for economic growth irrespective of the fact that the nature of the relationship and policy implications remain unsettled. As well noted by Vieira *et al*. (2013), exchange rate volatility, in addition to the level of the exchange rate and its misalignment, has an influence on trade and investment. This chapter contributes to the exchange rate-growth nexus debate by exploring the effect of exchange rate misalignment and volatility on economic performance in South Africa over the period 1985–2014.

The current economic climate in South Africa presents an interesting case study since the country is facing several challenges, with slow economic growth and high unemployment amongst the most challenging issues confronting policymakers. The South African National Development Plan 2030 (Economic Development Department), essentially a medium- to long-term plan aimed at increasing overall South African prosperity, identifies raising exports in areas such as mining, mid-skill manufacturing, agriculture and agro-processing as one of the ways to increase employment and boost economic growth in the country. Given the renewed interest in the relationship between exchange rate movements and economic performance, studying the influence of the exchange rate of the rand on the country's economic activity is worthwhile as the subject has received limited attention in the South African context. Moreover, the South African rand has been observed to exhibit cyclical appreciation and depreciation trends that coincide with high levels of volatility, and such patterns increase the likelihood of exchange rate misalignment, which might feed into long-term economic performance. Also noteworthy within this line of argument is the fact that South Africa is facing a declining manufacturing sector and a chronic current account deficit, the latter normally being cited as one of the most pertinent structural weaknesses in the economy (IMF, 2014).

The main objective of this essay is therefore to empirically explore the effects of exchange rate misalignment on the economic performance of South Africa. The study seeks to make a contribution to existing literature in the following manner: first, cointegration and error correction techniques based on the Autoregressive Distributed Lag (ARDL) method are used to test for the robustness of various misalignment indicators when included as an explanatory variable on a standard economic growth model. Secondly, and more specifically, the response of economic performance to exchange rate misalignment depending on the direction and size of misalignment is investigated. The study therefore seeks to ascertain whether the magnitude or size of the misalignment (small or large) and the direction (overvaluation or undervaluation) are important in explaining the economic output of the country. Although the focus of the study is on the asymmetric impact of misalignment on growth, another measure of exchange rate uncertainty – exchange rate volatility – is considered in order to assess which of the two is more important in influencing growth. The literature has mainly focused on the impact of volatility with inconclusive results; hence, this study considers whether a combination of misalignment and volatility could give explanations that are more meaningful. To the best of my knowledge, no prior study specific to South Africa has addressed the possible asymmetric impact of exchange rate misalignment on economic growth employing ARDL methods. Results from the study should provide country-specific evidence on the supposed positive influence of currency undervaluation on economic growth.

The essay is structured as follows: Section 4.2 provides a review of the literature on the subject. Section 4.3 provides an overview of the South African economy focusing on the relationship between economic growth and other variables relevant to the study. The methods used in the study are presented in Section 4.4, with the empirical results and concluding observations detailed in Sections 4.5 and 4.6 respectively.

4.2 LITERATURE REVIEW

4.2.1 Theoretical perspectives

Standard neo-classical growth theories have generally excluded the exchange rate when defining variables that determine economic growth (see Macdonald & Vieira, 2010; Schroder, 2013). As noted by Eichengreen (2007), the focus has largely been on factors that include education and training, savings, investment and technological progress as the fundamental drivers of economic growth. The economic success of several developing Asian nations observed in recent decades achieved through export promotion has, however, stimulated interest in the potential links between the exchange rate and economic growth. With many developing nations in search of the most appropriate policies to drive economic development, research on economic growth and the exchange rate has received increasing attention in less-developed nations.

Two main views can be identified in the literature regarding the economic impact of exchange rate misalignment. The first view is based on the principles of mercantilism and purports that an undervalued exchange rate promotes economic growth, whereas overvalued currencies hurt exports and impact economic performance negatively. In line with this view, Domac and Shabsigh (1999) suggest three ways in which exchange rate misalignment (especially in the case of an overvalued currency) can negatively affect economic growth. The first way is through overpricing of a country's exports, thus eroding external competitiveness. Such circumstances could lead to the deterioration of the country's external balance position, erosion of foreign exchange reserves and ultimately a sharp devaluation which will affect domestic prices and production. Secondly, exchange rate misalignment distorts relative prices (both domestic and international), in turn hurting efficiencies and hence the level of domestic investment and output. Lastly, a misaligned exchange rate promotes financial market volatility, which not only damages economic growth but also encourages currency speculation.

In support of the assertion that undervalued exchange rates can promote economic growth, Montiel and Serven (2009) cite China, Korea, Thailand and Chile as examples of countries that recently exhibited signs of high growth rates that were accompanied by undervalued real exchange rates and high domestic savings rates. They accordingly identify two channels through which an undervalued exchange rate can promote economic growth. The first channel is via promoting a shift in domestic production from non-traded to traded goods as the country's exports become more competitive in international markets. Such a move would be accompanied by productivity improvements throughout the economy that are supported by technology and skills transfers. The second channel is through boosting domestic savings, which, in turn, boosts economic growth through capital accumulation (Montiel & Serven, 2009). An overvaluation of the exchange rate would thus have the opposite effect on growth since it erodes the international competitiveness of domestic firms, thereby making it difficult for them to sell their products in the international markets (Dubas, 2012).

The second view relates to the 'Washington Consensus', which holds that exchange rate misalignment in any form is harmful to economic growth since it distorts a key relative price indicator in the economy. According to the Washington Consensus, attributed to Williamson (1990), an overvalued currency implies the existence of external imbalances, while exchange rate undervaluation indicates internal imbalances such that both directions of misalignment are bad for an economy. Schroder (2013) states that underpinning the Washington Consensus is the notion that there is an equilibrium REER that satisfies both external and internal balances, with any deviation of the exchange rate from this equilibrium level being detrimental to economic growth. Such a negative effect on growth could be driven by a misallocation of resources as investors form investment decisions based on relative prices in disequilibria and, since exchange rates adjust back to equilibrium over time, an undervalued currency might encourage investments into short-lived projects (Edwards, 1989). Nouira and Sekkat (2012) note that stable and better-aligned exchange rates were instrumental in supporting the growth of East Asian countries witnessed in the early 1990s, as opposed to Latin American and African countries that experienced factor misallocations, high inflation and low growth as a result of overvalued exchange rates observed over the same period. Thus, if both undervalued and overvalued exchange rates lead to a decline in economic growth, then the Washington Consensus holds. On the other hand, if economic performance responds differently to exchange rate overvaluation versus undervaluation, the response could be seen as asymmetric (with undervaluation effects mainly positive and the overvaluation impact negative).

There is good reason to believe that the economic effects of exchange rate misalignment could be asymmetric and nonlinear (i.e. the response can be different based on the direction and size of the misalignment). Pollard and Couglin (2004) cite export price and quantity rigidities, menu and switching costs and the competitive market structure within which firms in the tradable sector operate as the main theoretical arguments explaining the asymmetric impact of exchange rate movements. Regarding price rigidity, it is argued that exporters have the ability to raise their prices faster when the exchange rate depreciates (leading to an undervalued currency) than they are able to reduce prices when faced with an overvalued exchange rate, that is, prices are downwardly stickier than they are upwards (El Bejaoui, 2013). Given an undervalued exchange rate, quantity rigidities driven by either capacity constraints or trade restrictions could also inhibit the exporting companies’ ability to increase exports further (Delatte & López-Villavicencio, 2012). As indicated by Bussière (2013), in the presence of menu and switching costs, small movements in exchange rates may not induce exporters to adjust their prices (and hence export volumes) as it might be costly. Exporters would only change their prices once the currency movement reaches a certain threshold (large changes) whereby it would make economic sense to respond to such exchange rate movements. Kandil (2000) concludes that since currency depreciation raises net exports and production costs whilst an unanticipated appreciation of the exchange rate reduces exports, the combined effects of demand and supply channels may give rise to the asymmetric response of economic variables to exchange rate movements. The relative elasticities of foreign demand for local products and domestic demand for foreign products will in the end play a key role in the response to exchange rate movements (Svilokos & Tolić, 2014).

Although the level of the exchange rate (over- versus undervaluation) is important for growth, paying attention to the volatility of the exchange rate is also important since volatility can discourage investment and trade – both variables that are essential for economic growth. Bleaney and Greenaway (2001) observe that the influence of exchange rate volatility on growth is associated with the theory of investment, where the combination of uncertainty and irreversibility increases the value of the implied option to delay investments until the next period, such that economic growth is impeded. Since investment behaviour is influenced by uncertainty around future prices (e.g. exchange rates), market conditions and rates of return (especially in cases where investments are irreversible), exchange rate volatility therefore has the potential to increase the threshold necessary for expected returns to be reached before an investment is made (Carruth, Dickerson & Henley, 2000). If the Washington Consensus view holds such that exchange rate misalignment in any direction is undesirable, exchange rate misalignment, together with volatility of the exchange rate, could therefore represent forms of uncertainty that can influence investment decisions and, ultimately, economic growth. Eichengreen (2007), however, notes that the literature on the relationship between exchange rate volatility and growth is not definitive, with some studies indicating such relationship to be positive (e.g. Bailliu, Lafrance & Perrault, 2001) and others observing no relationship at all (e.g. Ghosh & Holger, 1997).

4.2.2 Selected empirical literature

Whether or not the Washington Consensus's view holds or the principles of mercantilism hold in a given country is an empirical question. Of the two views, the principles of mercantilism have received the most attention in previous studies. The empirical literature, however, provides limited support for the Washington Consensus view since most studies conclude that undervalued currencies can, in fact, promote economic growth (Sallenave, 2010; Schroder, 2013). In a highly influential study, Rodrik (2008a) investigated the principles of mercantilism, and found a positive relationship between an undervalued real exchange rate and economic growth in several developing countries (e.g. China, Uganda, Tanzania, Taiwan, India and South Korea). Using a panel of 184 countries and data from 1950 to 2004, Rodrik (2008a) developed a real exchange rate undervaluation index modelled as a deviation of the real exchange rate from its PPP level adjusted for the Balassa Samuelson effect (Glüzmann, Levy-Yeyati & Sturzenegger, 2012)[21]. When the undervaluation index is included in a growth equation, Rodrik (2008a) concluded that real exchange rate undervaluation promotes economic growth whilst exchange rate overvaluation has the opposite effect. Importantly, the author notes that such effects were more pronounced in developing countries such that the exchange rate could be used as an industrial policy instrument. Rodrik (2008a) does, however, warn that exchange rate misalignment should not be the only policy that seeks to drive economic growth, but must complement other broader macroeconomic initiatives. Rapetti, Skott and Razmi (2011) endorse the findings by Rodrik (2008a) that competitive real exchange rates are positively linked to higher

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[21] The two other popular approaches in the literature estimate misalignment as the deviation of the real exchange rate from an equilibrium level that satisfies the economy's internal and external equilibriums (FEER); or a deviation of the exchange rate from a level defined by the country's long-run economic fundamentals (BEER). This follows the fact that real exchange rates have been observed to depart for considerable periods from their PPP levels, thus making misalignments based on PPP levels inadequate. Águirre and Calderón (2005) also note that PPP only accounts for monetary factors that influence the exchange rate and neglects the real economic factors.

economic performance and emphasise that such an impact on growth is more predominant in not only poor countries but also middle income countries as opposed to developed nations.

The relationship between exchange rate misalignment and economic growth is also explored by Sallenave (2010) in a study that includes both developed and emerging economies (G20 countries). BEER methodology, where misalignment is measured as movements in the exchange rate away from an equilibrium level determined by a country's net foreign asset position and relative productivity differentials, is applied in the study to assess the influence of exchange rate misalignment on growth models that explain GDP *per capita* as a function of a vector of several economic variables. Using data covering the period 1980 to 2006, Sallenave (2010) found a negative and statistically significant relationship between real exchange rate misalignment and growth in real *per capita* GDP, concluding that exchange rate policy (especially for emerging market countries) that seeks to maintain the real exchange rate at its appropriate level would contribute positively to growth. Such findings provided credence to the Washington Consensus view that exchange rate misalignment in whichever direction is detrimental to economic growth.

Other notable studies on the link between currency misalignments and economic performance include Berg and Miao (2010), who seek to empirically compare the Washington Consensus view that real exchange rate misalignment is bad for growth against Rodrik's (2008a) widely accepted observation that undervalued exchange rates promote economic growth whilst overvaluations do not. The authors apply two estimates of exchange rate misalignment – one based on Rodrik's (2008a) undervaluation index (deviation from PPP adjusted for *per capita* income) and the other based on FEER methodology (deviation from a full set of determinants that include *per capita* income, terms of trade, openness, investment and government consumption). Berg and Miao's (2010) study confirms that exchange rate overvaluations are bad for growth whilst undervaluations contribute positively to growth. Such observations were consistent with Rodrik's (2008a) conclusion whilst not supporting the Washington Consensus. More studies that lend credence to the positive relationship between exchange rate undervaluation and economic activity include Elbadawi *et al.* (2012), who apply data from sub-Saharan African countries; MacDonald and Vieira (2010) on a sample of 90 countries. In a similar context, Naseem and Hamizah (2013) provide evidence from Malaysia; Abida (2011) from the Maghreb countries; Acar (2000), from a sample of 18 less-developed countries, and Ndhlela (2012) focuses on Zimbabwe.

On the possible asymmetry and nonlinearity in the response of economic growth to exchange rate movements, Razin and Collins (1997) are amongst the early notable contributors on the subject. Using data from 93 countries collected over the period 1972–1992, they develop a misalignment indicator based on a simple extension of an IS-LM model which is then added to a growth regression. In an effort to capture the differentiated impact of misalignment, they split the misalignment series into two sets (positive values to capture overvaluation and negative figures for undervaluation), which are then separately introduced to the growth equation. In order to account for the size of misalignment, the authors further subdivide the misalignment into low, medium, high and very high categories based on their relative distances from zero. Razin and Collins (1997) conclude that only very high overvaluations slowed growth, whilst moderate to high (not very high) undervaluations appeared to be positively associated with growth. Águirre and Calderón (2005) also explored the likelihood of an asymmetric relationship between exchange rate misalignment and economic growth on a sample of 60 countries from 1965-2003. Using panel cointegration methods, they likewise confirm nonlinearity since large misalignments, together with large undervaluations, had a negative effect on growth. Small to moderate undervaluations, on the other hand, appeared to enhance economic performance.

In a similar manner, Béreau, López-Villavicencio and Mignon (2012) used panel cointegration techniques and estimated panel smooth transition regression (PSTR) models to indicate that the effect of exchange rate misalignment on economic growth depends on the sign and extent of the misalignment. Relying on a broad sample of 32 countries drawn from both developed and developing countries and data from 1999 to 2004, the authors indicate that whilst an undervalued currency significantly enhances growth, currency overvaluation negatively affects economic performance. Béreau *et al.* (2012) used the differentiated and nonlinear effect of exchange rate misalignment on growth to show that appropriate exchange rate policies that limit overvaluation could have a positive impact on economic performance. This method was also followed by Couharde and Sallenave (2013) who applied PSTR methods to identify thresholds within which exchange rate undervaluations no longer have a positive impact on growth. Wong (2013) focused on country-specific (Singapore) asymmetry in the effects of misalignment on growth. The study applied ARDL cointegration methods to indicate that increases in exchange rate misalignment hurt economic growth, with undervaluation positively contributing to economic growth as opposed to overvaluations. The study however does not consider whether the size of misalignment really matters for the influence on growth. Other recent studies that have influenced the approach of this essay include Bussière (2013), Karoro, Aziakpono and Cattaneo (2009), El Bejaoui (2013), and Delatte and López-Villavicencio (2012) who study the asymmetric and nonlinear impact of exchange rate movements on either export and import prices or inflation.

As noted by Béreau *et al.* (2012), the possible impact of exchange rate misalignment on economic activity remains an open question, with numerous empirical contributions on the economic impact of exchange rate exploring the links between exchange rate volatility and economic growth. The general supposition from the literature, however, is that exchange rate overvaluation should affect output growth through compromising the competitiveness of the tradables sector and, if prolonged, could lead to unsustainable trade deficits and a possible currency crisis. Moderate undervaluations have the potential to encourage exports and investments, and hence economic growth, especially if such undervaluations are adjusted for productivity and inflation differentials (Zakaria, 2010). Such findings have emphasised the need for less-developed countries to constantly evaluate their approach to exchange rate policy to ascertain if there is room to use real exchange rate misalignment as an additional policy tool for influencing economic performance. Another notable observation from the literature is the fact that there is no consensus on how to measure exchange rate misalignments, whether as deviations from PPP or an estimated equilibrium level (MacDonald & Vieira, 2010).

Although the literature on exchange rate misalignment and economic growth has gained prominence in recent years, most of the empirical studies (e.g. Rodrik, 2008a; Sallenave, 2010; Elbadawi *et al.*, 2012) on the subject follow a panel data approach, with limited papers focusing on a single-country. Schroder (2013) observes that reliance on conventional panel data techniques imposes homogeneity suppositions concerning long-run exchange rate behaviour across countries – an assumption that does not necessarily hold. Nouira and Sekkat (2012), whose study fails to confirm a strong link between real exchange rate undervaluation and growth, also recommend the usage of individual country studies in an effort to draw meaningful conclusions regarding the relevance of exchange rate undervaluation as a driver of economic growth.

With specific reference to South Africa, most studies on the economic impact of exchange rates have mainly focused on the effects of exchange rate pass-through (ERPT) to inflation or prices. Such studies include Parsley (2012), Nogueira (2006), Karoro *et al.* (2009) and Aron, Farrell, Muellbauer and Sinclair (2012), all of which were mainly interested in the effects of exchange rate appreciations and depreciations on prices. With the external sector representing one of the key channels for linking exchange rates and economic growth, Rangasamy (2009) studied the relationship between exports and economic growth in South Africa, finding that there is uni-directional Granger-causality running from exports (especially non-primary exports) to economic growth. He concludes that policy initiatives that seek to stimulate export production could enhance the growth prospects of South Africa. In a different vein, Schaling and Kabundi (2014) tested for the J-curve effect in South Africa using data from 1994 to 2011 to confirm that a weaker REER boosts net exports in the long run. Their study shows that a depreciation in the real exchange rate in South Africa leads to a short-run deterioration in the trade balance, with the trade balance nevertheless improving in the long run (J-curve effect).

Some studies (e.g. Razin & Collins, 1997; Schroder, 2013; Couharde & Sallenave, 2013; Dubas, 2012) that specifically focus on exchange rate misalignment and economic growth and that have included South Africa as part of a panel study have produced mixed results. More specifically, Razin and Collins (1997) found that exchange rate overvaluation has a statistically significant negative effect on economic growth, with the results less convincing on the positive relationship between undervaluation and growth. Schroder's (2013) results, based on data from 1970-2007, lend support to the Washington Consensus view as the study suggests that deviations from an equilibrium exchange rate that is consistent with internal and external equilibrium lowers economic growth. Interestingly, Schroder (2013) found a negative relationship between real exchange rate undervaluation and economic growth in South Africa. Such a finding was attributed to economic difficulties experienced by the country during the period under review (including the oil price crisis, political and economic sanctions, and the debt crisis of the 1980s) which undermined confidence in the economy. Couharde and Sallenave (2013) found that although exchange rate undervaluation promotes economic growth, a level of undervaluation exceeding a threshold of 18.69% was contractionary for the sample of countries studied, including for South Africa.

Literature on the influence of exchange rate volatility on economic growth is widely inconclusive. From a theoretical perspective, exchange rate volatility represents a form of uncertainty that influences the decisions of investors and exporters such that when such risk is high, it could discourage international trade and investment (Choudhry & Hassan, 2015). Aghion, Bacchetta, Ranciere and Rogoff (2009) observe that regardless of the perceived centrality of the exchange rate regime to long-run growth and economic performance, existing theoretical and empirical literature offers little guidance on the matter, with exchange rate policy being the most contentious aspect of macroeconomic policy in developing countries. They note that as an example, the SARB is always chastised for an indifferent policy to counter exchange rate volatility, whilst China's relatively inflexible approach to exchange rate management has drawn intense international criticism. Aghion *et al* (2009) argue that higher levels of exchange rate volatility adversely affect growth, with the key transmission channel being through lower investment. In a similar context, using data from 41 EMU periphery countries, Schnabl (2007) finds that there exists a positive influence of exchange rate stability on growth as stability enhances trade, capital flows and macroeconomic stability.

Fang, Lai and Miller (2006) state that movements in exchange rates affect exports and hence economic growth in two ways: depreciation (undervaluation in this case) and volatility (see also Fang & Miller, 2007). If an undervalued exchange rate promotes exports whilst volatility concomitantly impedes trade, it might be necessary to consider the net impact on exports of the two potentially offsetting effects. An issue not addressed by Fang and Miller (2007) is appreciation (or overvaluation of the exchange rate) such that a combination of an overvalued and highly volatile exchange rate could compound the negative effects on exports and economic performance. This makes it important to consider both channels (i.e. misalignment and volatility) since the benefits realisable from exchange rate undervaluation could be dominated by the negative effect from volatility, leading to either a zero or negative net outcome on exports and economic growth. This issue has been largely ignored in the literature, with most studies focusing on either of the two factors in isolation.
From an empirical point of view, a three-step approach is usually followed to study the influence of exchange rate movements on economic growth. The first step is to estimate the equilibrium real exchange rate either through PPP, BEER or FEER methods. Secondly, the extent of misalignment is calculated as a deviation of the actual exchange rate from the equilibrium level. Lastly, the misalignment series is used as one of the explanatory variables in a standard growth model to assess if it has any influence. In order to capture the possibility of asymmetry and nonlinearity, the common approach in recent studies has been to split the misalignment variable into two series (positive values

for overvaluation and otherwise for undervaluation) and apply thresholds to differentiate between small and large changes (e.g. Karoro *et al.*, 2009; Bussière, 2013). The notable lack of country-specific studies on the subject and the conflicting findings from panel studies motivate for a further analysis with a focus on country-specific cases. This study contributes to the existing body of literature by providing evidence on the exchange rate misalignment-growth debate through using country-specific (i.e. South African) data. The study will answer the following questions: do REER misalignments in South Africa hinder growth? Do undervaluations enhance growth as opposed to overvaluations? Does the growth effect depend upon the size of the overvaluation or undervaluation? Lastly, the study considers whether a combination of exchange rate uncertainties as represented by both misalignment and volatility have an influence on South Africa's economic growth.

4.3 ECONOMIC GROWTH AND EXCHANGE RATE MOVEMENTS IN SOUTH AFRICA

The historical relationship between exchange rate misalignment[22] and GDP growth (quarter on quarter) for South Africa is presented in Figure 4.1 below. As indicated in the graph, one cannot identify a clearly observable pattern in the link between the two variables. For example, between 1985 and 1988 the exchange rate was mostly overvalued whilst economic growth moved in a wide range between -4.8% and 6.0%. Over the period 1988Q2 to 1990Q4, the rand was slightly undervalued (at about -4% on average) with growth consistently declining from 5.88% in 1998Q3 to -0.4% by 1990Q4. The pattern of declining economic growth rates continued until 1992Q3 (reaching -4.6%) with the exchange rate slightly overvalued at around 2% over the period 1998 to 1992. Economic growth recovered between 1993 and 1994 with the exchange rate close to its equilibrium level over this period. It is important to note that in the period before 1994, volatility in the exchange rate and poor economic growth were the result of the prevailing political situation in South Africa at the time (apartheid regime) and the resultant trade and financial sanctions imposed on the country. A managed float exchange rate regime existed in this era, with the Reserve Bank using interventions in the foreign exchange market and exchange controls to try and limit capital flight and influence the direction of the exchange rate.

South Africa's economic growth improved after 1994 following the transition to democracy due to trade openness and increased capital inflows which revived investment expenditure and sentiment (Du Plessis & Smit, 2007). As observed by Faulkner and Loewald (2008), factors supporting the economic recovery and strong growth after 1994 were macroeconomic policy reforms aimed at harnessing the benefits of globalisation, improving terms of trade and demand for the country's exports, and a monetary policy framework that helped anchor inflation at lower levels. These policy reforms also saw the SARB adopt a freely floating exchange rate policy which complemented the

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[22] Exchange rate misalignment series used in Figures 4.1 and 4.2 is sourced from Khomo and Aziakpono (2016), available at https://econrsa.org/publications/working-papers/behaviour-real-effective-exchange-rate-south-africa-there-misalignment.

inflation targeting regime. From a mere average annual economic growth rate of 1% between 1984 and 1993, the country experienced average growth rates of 3% and 5.1% over the periods 1994-2003 and 2004-2007 respectively (Faulkner & Loewald, 2008). Between 1994 and early 1998, the REER was overvalued by close to 10%, with economic growth mainly positive over the same period. From 1998 to 2001, the rand depreciated heavily, with the currency reaching its highest recorded level of undervaluation (-22.1%) in 2002 with quarterly GDP growth rates averaging around 3% over the same period. Over the period 1998 and 2003 one can observe a positive relationship between an undervalued rand and economic growth (Figure 4.1).

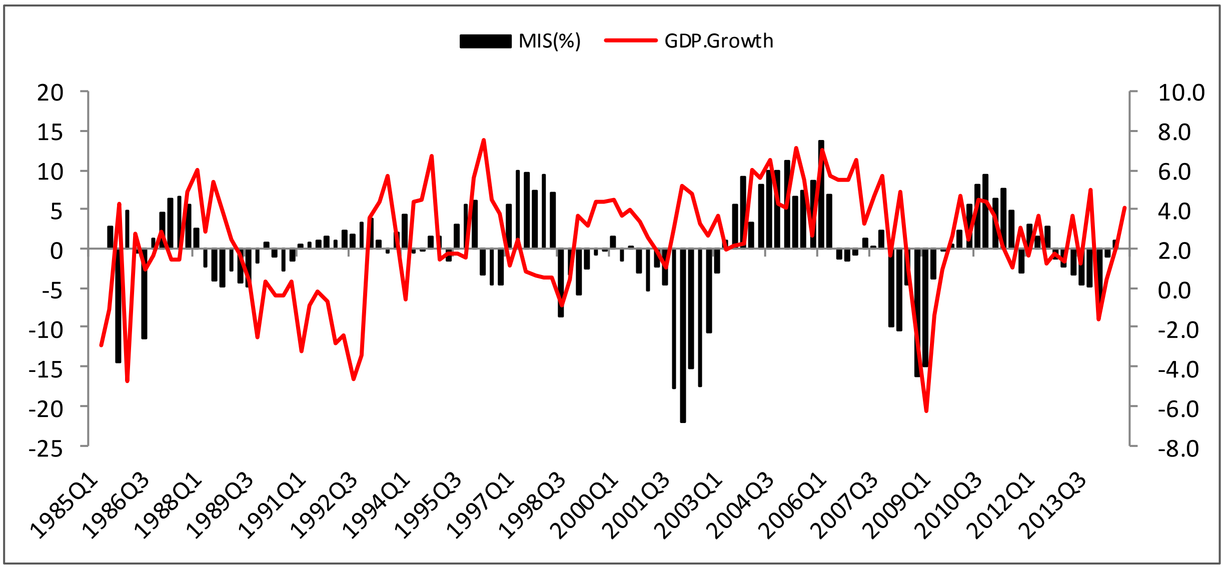

Figure 4.1: GDP growth and exchange rate misalignment

Data sources: SARB Quarterly Bulletin; Khomo and Aziakpono (2016)

Following this period of steep depreciation and undervaluation, the currency recovered with the REER thereafter moving into overvaluation territory between 2003 and 2006. The strong economic growth observed from 1998 continued over this period although the currency was overvalued. The 2008 global financial crisis introduced a new period of low economic growth that was accompanied by further rand variations between undervaluation and overvaluation. A steep decline in economic growth between 2008 and 2009 was accompanied by an undervalued exchange rate. The currency recovered between 2012 and 2014 (REER moving into overvaluation) and this was supplemented by a recovery in economic growth although to lower levels than pre-1998. Slight exchange rate undervaluation together with low but positive economic growth can be observed between 2013 and 2014. In a nutshell, although one would expect exchange rate undervaluation to be accompanied by high economic growth and overvaluation having the opposite effect, such a relationship cannot be conclusively determined from Figure 4.1.

4.4 ANALYTICAL FRAMEWORK AND EMPIRICAL MODEL

Evaluating the impact of exchange rate misalignment on economic growth involves two key steps. The first step is to empirically estimate the equilibrium REER (e.g. via an application of PPP, BEER or FEER theoretical methods) and then measure the extent of misalignment (i.e. deviation of the observed REER from the estimated equilibrium level). With the equilibrium exchange rate unobservable, no benchmark exists to validate the results from the various exchange rate models, thus rendering exchange rate modelling challenging and controversial (Zakaria, 2010). The exchange rate misalignment indicator is therefore heavily influenced by the estimation method applied. The second step allows for the inclusion of the misalignment series obtained in the first step as one of the explanatory variables in a standard growth model (see Berg & Miao, 2010; Sallenave, 2010; Abida, 2011). With the main focus of this study being the assessment of the economic impact of exchange rate misalignment, less attention is paid in this study to the modelling of exchange rate misalignment and the misalignment series obtained from Chapter 2 of the thesis is used. The chapter applies the BEER method to model the equilibrium exchange rate as a function of net capital flows, terms of trade, external openness and government expenditure. The BEER methodology allows the equilibrium exchange rate to change over time as it tracks movements in the country's economic fundamentals and domestic policies (Béreau *et al.*, 2012).

4.4.1 Misalignment and economic growth

To investigate the impact of exchange rate misalignment on growth, the approach employed by previous studies are followed where the misalignment series is added amongst the explanatory variables in a normal empirical growth equation (see Tarawalie, 2010; Wong, 2013; Sallenave, 2010; Naseem & Hamizah, 2013). The proposition is that exchange rate misalignment will likely have a significant effect when added to such a growth model (Zakaria, 2010). Nouira and Sekkat (2012) note that one fundamental challenge with empirical growth research is the lack of consensus on the variables that should be regressors in an empirical growth model. The approach in this study is hence to consider a set of core control variables that are predominantly featured in economic growth models and assess the statistical significance of the misalignment variable when included amongst such growth determinants. Several variables were considered, including domestic investment, government expenditure, external openness, terms of trade, money supply, real interest rates, inflation and global GDP. More specifically, a standard growth model (e.g. along the lines of Acar, 2000), augmented with a misalignment indicator specified as follows, is estimated:

$$Lgdp_t = \beta_0 + \beta_1 Linv_t + \beta_2 Lopen_t + \beta_3 cpi_t + \beta_4 MIS_t + u_t \qquad ...(4.1)$$

where *Lgdp* represents the log of real GDP, *Linv* is the ratio of investment to GDP (log form), *cpi* is the consumer price inflation rate, *Lopen* (log form) is the measure of external openness, and MIS_t is the measure of exchange rate misalignment. The variable of interest in this model is MIS_t (β_4) since the main aim of the study is to assess the impact of exchange rate misalignment on economic growth.

The coefficients β_1 and β_2 are expected to be positive, with β_3 having a negative sign. The Washington Consensus view postulates that the coefficient β_4 should be negative since any form of exchange rate misalignment from the equilibrium level is bad for economic growth[23].

The most popular approach followed in the literature (e.g. Berg & Miao, 2010; Ndhlela, 2012) when assessing the impact of exchange rate misalignment on growth has been to include the misalignment variable as a single series in Equation 4.1. The main shortcoming of this approach is that one fails to disaggregate the possible asymmetric impact of exchange rate misalignment (Schroder, 2013; Couharde & Sallenave, 2013). Nouira and Sekkat (2012) address the issue of asymmetry by splitting the misalignment indicator into two series: one with values for overvaluation only (positive values) and the other with the values for undervaluation (negative values). This approach is also applied in studies that consider ERPT asymmetry such as Pollard and Coughlin (2004) and Bussière (2013). More specifically, such a method allows one to separate the misalignment series in terms of direction as follows:

$$Over\_val_t = \begin{cases} Mis_t \text{ if } Mis_t > 0 \\ 0 \text{ otherwise} \end{cases}$$

$$Under\_val_t = \begin{cases} Mis_t \text{ if } Mis_t < 0 \\ 0 \text{ otherwise} \end{cases} \quad \ldots(4.2)$$

where *Over_val*$_t$ and *Under_val*$_t$ correspond to exchange rate over- and undervaluation periods respectively. This study also considers an alternative approach followed by scholars such as Karoro *et al.* (2009), Schroder (2013) and El Bejaoui (2013), and constructs new variables that separately account for partial cumulative exchange rate over- and undervaluation episodes. As per this approach, the misalignment series is constructed into two variables: *Over_val1*$_t$; and *Under_val1*$_t$ as follows (see Delatte & López-Villavicencio, 2012):

$$Over\_val1_t = \sum_{j=1}^{t} \Delta MISt(+) = \sum_{j=1}^{t} \max(\Delta MISt, 0);$$

$$Under\_val1_t = \sum_{j=1}^{t} \Delta MISt(-) = \sum_{j=1}^{t} \min(\Delta MISt, 0) \quad \ldots(4.3)$$

where $\Delta MIS_t(+)$ and $\Delta MIS_t(-)$ are the partial (accumulated) sum of over- and undervaluation episodes respectively. An extended version of Equation 4.1 that aims to capture the asymmetric effects of under- and overvaluation (applying the series generated in Equation 4.2 therefore becomes[24]:

$$Lgdp_t = \beta_0 + \beta_1 Linv_t + \beta_2 Lopen_t + \beta_3 cpi_t + \beta_4 Over\_val_t + \beta_5 Under\_val_t + u_t \quad \ldots(4.4)$$

[23] The growth equation (4.1) would therefore represent a standard measure of empirically testing for the Washington Consensus view.

[24] Equation 4.4 makes it possible to test for Rodrik's (2008a) view that exchange rate undervaluation is likely to have a different impact on growth than exchange rate overvaluation.

The ARDL bounds testing methodology (attributed to Pesaran & Shin (1999) and Pesaran, Shin and Smith (2001)) is used to test for cointegration and study the impact of exchange rate misalignment on economic growth. As noted in previous studies (Roudet, Saxegaard & Tsangarides, 2007; Kyophilavong, Shahbaz & Uddin, 2013; Kumar, 2010), the main benefit of the ARDL method compared to other cointegration techniques (such as Engle and Granger (1987) and Johansen and Juselius (1990)) is its applicability irrespective of whether the underlying variables are purely I(0), purely I(1) or have a mixed order of integration, thus removing any uncertainty regarding the analysis[25]. Other benefits of this approach are its robustness and good performance in small samples, coupled with the fact that when the model includes endogenous regressors, it provides valid t-statistics and unbiased long-run estimates (Odhiambo, 2008). Finally, endogeneity is less problematic in the ARDL framework since the model is free of residual correlation with the method able to distinguish between dependent and explanatory variables (Jalil, Mahmood and Idresss, 2013[26]).

Transforming the basic (symmetric) growth model (4.1) into an ARDL specification gives the following equation:

$$\Delta Lgdp_t = \Theta_0 + \lambda_1 Lgdp_{t-1} + \lambda_2 Linv_{t-1} + \lambda_3 Lopen_{t-1} + \lambda_4 cpi_{t-1} + \lambda_5 MIS_{t-1} + \sum_{i=1}^{n} \delta_1 \Delta Lgdp_{t-i} + \sum_{i=1}^{n} \delta_2 \Delta Linv_{t-i} + \sum_{i=1}^{n} \delta_3 \Delta Lopen_{t-i} + \sum_{i=1}^{n} \delta_4 \Delta cpi_{t-i} + \sum_{i=1}^{n} \delta_5 \Delta MIS_{t-i} + u_t \quad \ldots(4.5)$$

with Δ denoting the first difference operator, λ_i the long-run multipliers and δ_i the short-run multiplier terms. The ARDL bounds testing procedure follows two steps: the first tests for the presence of a long-run relationship among the variables. The F-test for the joint significance of the coefficients of the lagged levels of the variables is applied to test for the presence of a long-run relationship. Under such a test (Kumar, 2010), the null hypothesis of no cointegration among the variables in Equation 4.5 is denoted by H_o: $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$, against the alternative H_a: $\lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq \lambda_5 \neq 0$. The computed F statistic is compared to the critical values computed by Pesaran *et al.* (2001) and if the F-statistic falls below the lower bound value I(0), the null hypothesis of no cointegration cannot be rejected. Likewise, if the F-statistic exceeds the upper bound value I(1), the null hypothesis of no cointegration is rejected. However, if the value is within the lower and upper bound, then the test is inconclusive. Upon confirming existence of a cointegrating relationship, long- and short-run parameters of the model are then estimated in the second step.

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[25] The ARDL method does not require that the variables to be integrated of the same order in order to find cointegration, as opposed to the Johansen methodology where such a requirement is crucial.

[26] The assumption that the dependent variable in an ARDL is endogenous could be a limitation of the model as this might not hold. Since this study is mainly interested in the possible influence of misalignment on the growth model, Granger Causality tests are used to supplement the results obtained from the ARDL model.

I specify various models based on Equation 4.5 where the under- and overvaluation series are either entered separately or jointly to the long-run cointegrating model in an effort to test for asymmetry in the link between economic growth and exchange rate misalignment. An asymmetric ARDL version of the growth model (4.5), which allows me to test whether GDP growth reacts in a similar manner to the over- and undervaluation episodes (as in Equation 4.5), is represented by the equation:

$$\Delta Lgdp_t = \Theta_0 + \lambda_1 Lgdp_{t-1} + \lambda_2 Linv_{t-1} + \lambda_3 Lopen_{t-1} + \lambda_4 cpi_{t-1} + \lambda_5 Over\_val_{t-1} + \lambda_6 Under\_val_{t-1} + \sum_{i=1}^{n} \delta_1 \Delta Lgpd_{t-i} + \sum_{i=1}^{n} \delta_2 \Delta Linv_{t-i} + \sum_{i=1}^{n} \delta_3 \Delta Lopen_{t-i} + \sum_{i=1}^{n} \delta_4 \Delta cpi_{t-i} + \sum_{i=1}^{n} \delta_5 \Delta Over\_val_{t-i} + \sum_{i=1}^{n} \delta_6 \Delta Under\_val_{t-i} + u_t \quad \ldots(4.6)$$

Equation 4.6 denotes the likelihood that the impact of exchange rate misalignment on GDP may exhibit asymmetries over either both the short and long run, only over the short run or only over the long run (Delatte & López-Villavicencio, 2012). The hypothesis test for long-run symmetry is such that H_0: $\lambda_5 = \lambda_6$ against H_1: $\lambda_5 \neq \lambda_6$, with the Wald test used to assess such a hypothesis. The results from Equation 4.6 are compared with different models that include partial sum overvaluation and undervaluation episodes (denoted by $Over\_val1_t$ and $Under\_val1_t$ respectively) and total cumulative overvaluation and undervaluation episodes (denoted by *Over_valcum and Under_valcum* respectively) over the sample period.

4.5 RESULTS

4.5.1 Data description

In an effort to identify the economic performance model to be applied in the study, several variables were considered for inclusion in the form economic indicators that are theoretically sound, appear in the literature and have data readily available. For the dependent variable, series considered were GDP per capita (both the level and growth) and real GDP (levels and growth). For explanatory variables, investment, savings, population growth, trade (imports and exports), external openness, terms of trade, CPI and government expenditure were explored, with the choice of variables considered also influenced by how easily available the data was. The final model was chosen after trying several combinations of the identified variables in order to arrive at one that is meaningful enough to make inference about the potential influence of the exchange rate. Acar (200) is hence followed where the response variable (regressing) is economic output[27] (i.e. real GDP). Quarterly

[27] Most studies (e.g. Rodrik 2008a, Dubas 2012) that explore the impact of the exchange rate on economic growth estimate a neoclassical growth model that uses GDP per capita growth as the explanatory variable. Since this study used real GDP as the dependent variable, the model is hence not a full neoclassical growth model such that other common explanatory variables such as technological change and population growth are not present.

data from 1985Q1 to 2014Q4 was used for the empirical analysis. The dependent variable GDP and was sourced from the SARB. External openness is represented as the sum of exports plus imports divided by GDP, with investment as the ratio of gross fixed capital formation to GDP, and inflation is consumer price inflation (CPI). These variables were also obtained from the SARB[28].

4.5.2 Equilibrium exchange rate and misalignment

The REER misalignment series applied in the study are based on the empirical model estimated in the second essay of this thesis (Chapter 3). In the study, the Johansen procedure was used in a BEER framework to confirm the presence of a long-run relationship between the REER and the terms of trade (including gold), external openness, government expenditure and net capital flows. Subsequent to confirming cointegration of the variables and the endogeneity of the exchange rate in the model, the DOLS method was then applied to estimate the long-run cointegrating equation with the following result[29]:

$$LREER = 5.5924 + 0.8157ltot - 0.8533lopen + 0.5839k\_flows - 0.3677lgovt \quad \ldots(4.7)$$

Equation 4.7 is used to generate the equilibrium exchange rate and specify misalignment as departure (expressed as a percentage) of the actual REER from the HP filtered equilibrium level. Figure 4.2 confirms the presence of frequent deviations of the observed exchange rate of the rand from its estimated equilibrium levels. Steep movements in one direction (e.g. undervaluation) have normally been followed by corrections that tend to push the exchange rate in the other direction (i.e. overvaluation). Shocks to exchange rate movements (and hence misalignment) have been mainly driven by external factors (e.g. the recent global financial crisis) in recent years. The study found that the exchange rate of the rand was more undervalued than overvalued in the period of the study. The misalignment series computed above provides a key explanatory variable for the growth model estimated in this study.

4.5.3 Misalignment and economic growth

4.5.3.1 Stationarity tests

Prior to conducting the bounds cointegration test, unit root tests were performed on the variables to understand their order of integration. The results obtained are reported in Table 4.1. Although the ARDL method does not necessitate all variables to be integrated of order 1 (i.e. I(1)), it is important that the variables are not I(2) as the F-test would provide spurious results (Odhiambo, 2008). The ADF and Breakpoint Unit Root tests are used to test for stationarity of the series. Both test statistics

[28] Tables 6.1 and 6.2 in the appendix provide the summary descriptive statistics and pairwise correlations for the variables used.
[29] The results for all the fundamentals were consistent with the empirical literature with the coefficients significant at 5% levels.

confirm that the order of integration of the variables to enter the growth model are mixed, and hence validate the suitability of the ARDL model (Table 4.1).

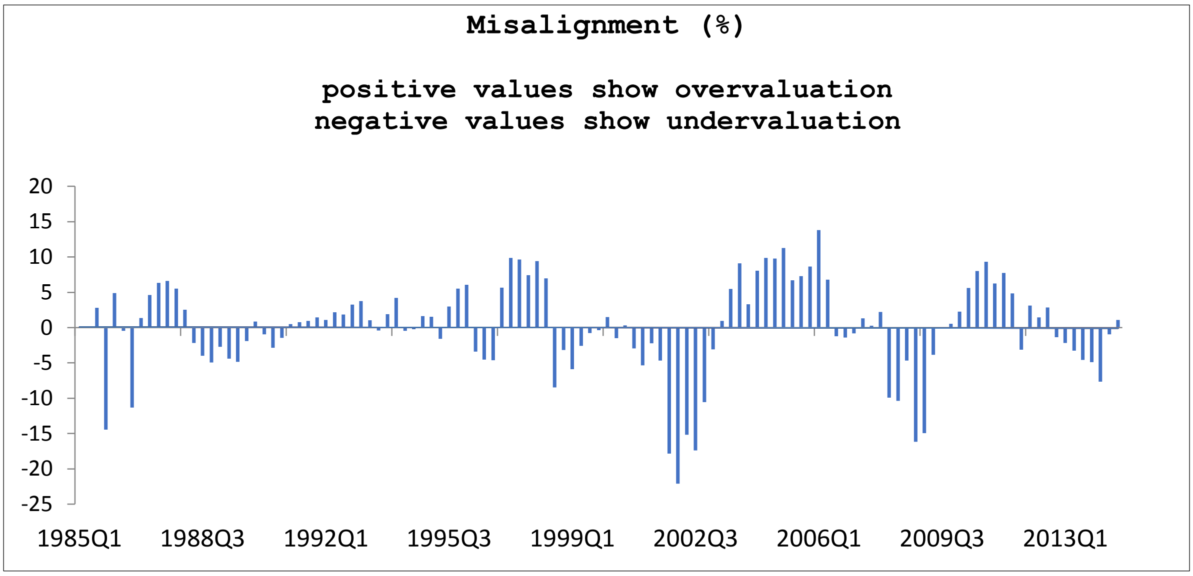

Figure 4.2: Exchange rate misalignment

Source: Author's own calculations (Chapter 2)

The Breakpoint Unit Root Test is used to supplement results from the ADF tests since it is robust in the presence of a structural break in the series being studied, thus enhancing the robustness of the conclusions about the data generating process. In addition, the ARDL model remains applicable in the presence of structural breaks in the variables if the short-run and long-run coefficients are stable based on the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) tests. The CUSUM and CUSUMQ tests are quite general tests for structural change in that they do not require a prior determination of where the structural break takes place and these tests can be used to ascertain whether any underlying structural breaks have affected the long-run stability of the estimated coefficients. As suggested by Pesaran (1997), the CUSUM and CUSUMQ tests proposed by Brown *et al.* (1975) can be applied to the residuals of the estimated error correction models to test parameter constancy (see Ozturk and Acaravci, 2011). These are reported. Other formal tests such as the Quandt-Andrews test can be employed to formally examine the data and formally identify structural breaks. The variables cpi, Mis_t, Over_val, under_val, and vol_t are all stationary at level (i.e. I(0)), with the other variables stationary after first difference (i.e. I(1)).

4.5.3.2 Cointegration test results

In this section the results of the cointegration test for both the symmetric (Equation 4.5) and the various asymmetric models (based on Equation 4.6) are presented. The ARDL bounds testing procedure is applied to test for cointegration among the variables. Tables 4.2 and 4.3 report the computed F-statistics and respective critical values for testing the presence of a long-run relationship between the variables. For the symmetric estimation, the F-statistic falls outside the upper bounds whilst statistically significant at the 1% level of significance (see Table 4.2). This result confirms the presence of a long-run relationship between real GDP and the selected variables (including exchange rate misalignment).

Table 4.1: Unit root tests

Augmented Dickey-Fuller					
Level			**First Difference**		**Conclusion**
Variable	**Intercept**	**Intercept & Trend**	**Intercept**	**Intercept & Trend**	
lgdp	0.71	-1.79	-5.87***	-5.98***	I(1)
lopen	-1.60	-2.91	-12.44***	-12.43***	I(1)
linv_gdp	-2.23	-2.20	-3.69***	-3.70**	I(1)
cpi	-4.48***	-5.91***	-11.74***	-7.99***	I(0)
Mis_	-4.52***	-4.50***	-13.04***	-12.99***	I(0)
Over_val	-4.02***	-4.014**	-11.01***	-10.97***	I(0)
Over_valcum	-0.41	-2.86	-4.01***	-3.99**	I(1)
Under_val	-5.15***	-5.13***	-13.87***	-13.81***	I(0)
Under_valcum	0.19	-2.68	-5.28***	-5.33***	I(1)
Vol_t	-5.932***	-5.952***	-15.061***	-14.996***	I(0)
Breakpoint Unit Root Test					
Level			**First Difference**		**Conclusion**
Variable	**Intercept**	**Intercept & trend**	**Intercept**	**Intercept & Trend**	
lgdp	-1.66	-3.47	-6.73***	-7.15***	I(1)
lopen	-3.25	-4.16	-13.21***	-13.25***	I(1)
linv_gdp	-2.95	-3.79	-4.20*	-4.62*	I(1)
cpi	-7.01***	-7.30***	-12.28***	-12.21**	I(0)
Mis_	-4.95***	-5.06**	-13.76***	-13.66**	I(0)
Over_val	-4.71**	-5.02**	-11.83***	-11.74***	I(0)
Over-valcum	-2.89	-5.13**	-4.70**	-4.97**	I(1)
Under_val	-5.94***	-5.79***	-14.98***	-15.01***	I(0)
Under_valcum	-2.87	-5.43***	-6.22***	-6.10***	I(1)
Vol_t	-8.822***	-9.003***	-20.692***	-20.677***	I(0)

*; **; *** denote significance at 10%, 5% and 1% respectively

Table 4.2: ARDL bounds test (symmetric model):

ARDL bounds test for cointegration		
F-Statistic	9.0726***	
Asymptotic critical values		
	I(0)	**I(1)**
10%	2.20	3.09
5%	2.56	3.49
1%	3.29	4.37

*; **; *** denote significance at 10%, 5% and 1% respectively

Table 4.3: ARDL bounds test (asymmetric models)

	Over_val & Under_val		Over_valcum & Under_valcum[#]	
F-Statistic	8.4003***		9.6694**	
Asymptotic critical values				
	I(0)	I(1)	I(0)	I(1)
10%	2.08	3.00	2.08	3.00
5%	2.39	3.73	2.39	3.73
1%	3.06	4.15	3.06	4.15

*; **; *** denote significance at 10%, 5% and 1% respectively
[#] represents the total accumulated over- and undervaluations respectively

Table 4.3 reports the ARDL bounds test results for the different specifications allowing for asymmetry. It can accordingly be confirmed that a long-run relationship exists between economic growth and the variables chosen in two of the models. The model that includes partial (accumulated) sum over- and undervaluation episodes (Equation 4.6: *over_val1* and *under_val1*) shows no long-run relationship and hence is excluded from further analysis. The estimated long- and short-run coefficients of the symmetric model are presented in Table 4.4.

The results in Table 4.4 show that the exchange rate misalignment variable (Mis_) is positive (although marginally so) but not statistically significant, suggesting that exchange rate misalignment (as represented in the symmetric model) has no impact on economic performance in South Africa. The finding is inconsistent with the Washington Consensus view (Rodrik, 2008a), which implies that exchange rate misalignment in whatever direction has a negative impact on growth. The results also show that the external openness and inflation variables have the expected signs (positive and negative effects on GDP respectively), with the variable for investment expenditure showing the correct positive sign though statistically insignificant[30]. Such results provide motivation to test for a possible asymmetric impact of the exchange rate's influence on growth, which is reported next in Table 4.5.[31]

Table 4.4: Symmetric ARDL model results

Long- and short-run estimates of the ARDL symmetric model		
Panel A: Long-run coefficient estimates: Dependent variable is lgdp		
ARDL(2,0,0,3,0)		
Variable	**coefficient**	**t-statistic**
Lopen	0.911	4.034***
linv_gpd	0.095	0.324
cpi	-0.045	-3.613***
Mis_	0.005	0.972
constant	11.272	13.537***
Panel B: Short-run coefficient estimates: Dependent variable is Δlgdp		
$\Delta lgdp_{t-1}$	0.317	3.878***
Δcpi	-7. 52E-05	-0.573
Δcpi_{t-1}	0.001	4.399***
Δcpi_{t-2}	0.001	3.610***
ECM_{t-1}	-0.019	-6.958***
LM Test# 1.394 (0.253)		
White Test ## 2.450 (0.001)		
CUSUM: S	**CUSUMQ: S**	

*; **; *** denote significance at 10%, 5% and 1% respectively
represents the Breusch-Godfrey Serial Correlation LM Test and ## the Heteroskedasticity White Test
For CUSUM and CUSUMQ: S is stable and U is Unstable

[30] The model has a negative and statistically significant error correction term as well implying that deviations in the short run are corrected back to equilibrium in subsequent quarters..
[31] Eviews 9 was used for estimating the ARDL models reported in this study.

Table 4.5: Long- and short-run estimates of asymmetric ARDL models

	Model 1 (Over_val & Under_val)		Model 2 (Over_valcum & Under_valcum)	
	ARDL(2,0,0,3,0,0)		ARDL(2,0,0,3,0,1)	
Variable	**coefficient**	**t-statistic**	**coefficient**	**t-statistic**
Panel A: Long-run coefficient estimates				
lopen	1.019	4.968***	0.329	2.637***
linv_gpd	0.027	0.110	0.069	1.271
cpi	-0.042	-3.968***	-0.011	-2.418**
Under_val	0.014	2.109**	-	-
Over_val	-0.006	-0.777	-	-
Under_valcum	-	-	-0.001	-5.023***
Over_valcum	-	-	0.001	1.692*
constant	11.048	15.942***	12.944	33.664***
Panel B: Short-run coefficient estimates				
$\Delta lgdp_{t-1}$	0.305	3.659***	0.368	4.744***
Δcpi	-3.50E-05	-0.267	6.36E-06	0.0477
Δcpi_{t-1}	0.001	4.570***	0.001	4.325***
Δcpi_{t-2}	0.001	3.576***	0.001	3.989**
ΔUnder_valcum			0.0001	1.903*
ECM_{t-1}	-0.0211	-6.931***	-0.077	-6.791***
Wald test 1.875 (0.063)			0.847 (0.398)	
LM Test# 1.182 (0.320)			1.151 (0.332)	
White Test## 2.386 (0.001)			2.884(0.001)	
CUSUM: S	CUSUMQ: S		CUSUM: S	CUSUMQ: S

*; **; *** denote significance at 10%, 5% and 1% respectively
represents the Breusch-Godfrey Serial Correlation LM Test and ## the Heteroscedasticity White Test
For CUSUM and CUSUMQ: S is stable and U is unstable both at a 5% level of significance.

Table 4.5 reports results from the two asymmetric model specifications. Although not conclusive at this point, an important finding here is confirmation that economic performance does not react in a similar manner to exchange rate overvaluation as do undervaluation episodes (see the asymmetric model results in Table 4.5 above). The long-run coefficient for undervaluation (*Under_val*) in the baseline asymmetry model (Model 1: *Over_val* vs *Under_val*) is both positive and statistically significant, thus indicating that an undervalued exchange rate promotes economic growth. Though statistically insignificant, the coefficient for overvaluation is negative, suggesting that exchange rate overvaluation can indeed be detrimental to economic growth in the long-run. The Wald test (i.e. the test for $\lambda_5 = \lambda_6$: *Over_val* = *Under_val* as per Equation 4.6) also makes it possible to reject the null hypothesis of long-run symmetry at a 10% level of significance (t-statistic: 1.875). Diagnostics tests show that this model is normally distributed, free from serial correlation and heteroscedasticity. A similar conclusion is reached where each series enters the growth equation alone with the undervaluation coefficient positive and statistically significant (at 10%) and overvaluation negative although not statistically significant. Lastly the CUSUM and CUSUMQ test statistics for both models fall inside the critical bounds of the 5% level of significance, implying that the estimated parameters are stable over the period studied (Figure 4.2 below shows the CUSUM and CUSUMQ statistics for the baseline asymmetry model: Model 1 - under_val and over_val).

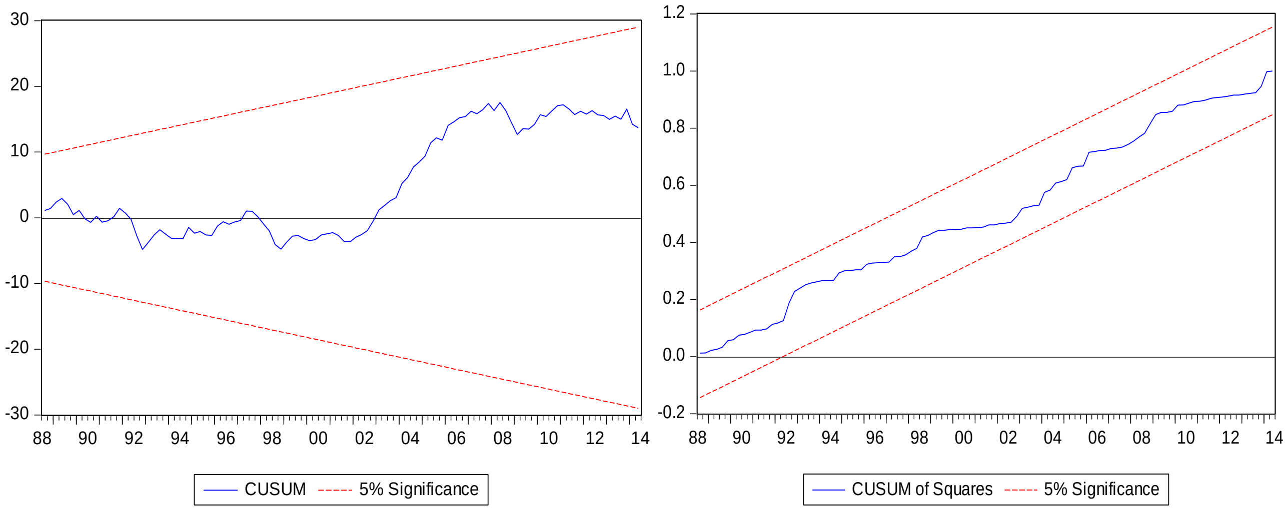

Figure 4.3: CUSUM and CUSUMQ statistics for baseline asymmetry model

Although the ARDL cointegration method is able to test for the presence of a long-run relationship between economic growth and exchange rate misalignment episodes, the method does not indicate the direction of causality (Jalil *et al.*, 2013). In an effort to enhance the conclusions, an error-correction based Granger causality test is conducted to supplement the results from the ARDL model and examine the causal relationship between economic performance and exchange rate over and undervaluation. Such an approach is applied in other studies that include Ozturk and Acaravci, 2011, Odhiambo, 2004; 2009; Narayan and Smyth, 2009; and Jalil *et al*., 2013. Odhiambo (2004) states that the error-correction based Granger Causality test is able to detect long-run causality via the significance of the error correction term obtained from the cointegrating equation when employed in a Granger causality test. Reported in Table 6.1 (Appendix 1) are the results from the Granger-Causality tests estimated from the baseline asymmetric model (overvaluation versus undervaluation). The causality test results confirmed the presence of a one-way long-run directional relationship from exchange rate misalignment indicators (overvaluation and undervaluation, and the error correction term) to economic performance.

4.6 DOES THE SIZE OF MISALIGNMENT MATTER?

The second asymmetric model (Table 4.5, Model 2: *Over_valcum* and *Under_valcum*), which seeks to capture misalignment persistence using the total cumulative misalignment series over the sample period, indicates a strongly significant negative impact of exchange rate undervaluation on economic growth. This suggests that an undervalued currency might be positively correlated with growth based on some threshold level, after which the effect of persistent misalignment on economic growth becomes negative. The coefficient for overvaluation is positive and contrary to theoretical expectations, although it is only statistically significant at a 10% level. The Wald test statistic for this model also fails to confirm asymmetry between the coefficients of cumulative under- and overvaluation. Such conflicting results prompt for further analysis in order to ascertain if there are levels or thresholds of misalignment which could be meaningful to influence economic performance. The concomitant question is therefore at what level does exchange rate undervaluation cease to have a positive impact on economic growth? Such a question is important for policymakers if an undervalued currency does indeed make a positive contribution to economic performance, and this question is explored next.

The study was therefore extended to ascertain whether the size (i.e. small or large changes) of exchange rate misalignment matters for economic growth. Karoro *et al.* (2009), working on ERPT to import prices, note that there is no standard measure of large or small changes if one wants to study the impact of the size of exchange rate variations. The approach taken in this study follows along the lines of Pollard and Coughlin (2004) and Bussière (2013), where certain thresholds, namely 3%, 5% and 10%, are specified to separate large and small misalignments. For example, a threshold based on 3% (for both overvaluation and undervaluation) that captures both the direction and size of exchange rate misalignment can be specified as follows:

$$L\_over\_v_t = \begin{cases} \text{Mist if } Mis_t > 3\% \\ 0 \text{ otherwise} \end{cases} \quad S\_over\_v_t = \begin{cases} \text{Mist if } 0 < Mis_t \leq 3\% \\ 0 \text{ otherwise} \end{cases}$$

$$L\_under\_v_t = \begin{cases} \text{Mist if } Mis_t < -3\% \\ 0 \text{ otherwise} \end{cases} \quad S\_under\_v_t = \begin{cases} Mis_t \text{ if } -3\% \leq Mis_t < 0 \\ 0 \text{ otherwise} \end{cases} \qquad \ldots(4.8)$$

where $L\_over\_v_t$ and $S\_over\_v_t$ represent episodes of large and small overvaluations respectively, and $L\_under\_v_t$ and $S\_under\_v_t$ are large and small undervaluations respectively.

The study again follows the approach of Karoro *et al.* (2009) and includes one of the series (e.g. small undervaluation; $S\_under\_v_t$) in the ARDL growth model to test for the impact of both the direction and size of the exchange rate misalignment. For example, the ARDL model specification for a large exchange rate undervaluation ($L\_under\_v_t$) is as follows:

$$\Delta Lgdp_t = \Theta_0 + \lambda_1 Lgdp_{t-1} + \lambda_2 Linv_{t-1} + \lambda_3 Lopen_{t-1} + \lambda_4 cpi_{t-1} + \lambda_5 L\_under\_v_{t1} + \sum_{i=1}^{n} \delta_1 \Delta Lgpd_{t-i} + \sum_{i=1}^{n} \delta_2 \Delta Linv_{t-i} + \sum_{i=1}^{n} \delta_3 \Delta Lopen_{t-i} + \sum_{i=1}^{n} \delta_4 \Delta cpi_{t-i} + \sum_{i=1}^{n} \delta_5 \Delta L\_under\_v_{t-i} + u_t \quad \ldots(4.9)$$

Table 4.6: Undervaluation series alone (different thresholds)

Misalignment thresholds								
	3%		**5%**		**7%**		**10%**	
Panel A: Long-run coefficient estimates								
	L_under_vt	**S_under_vt**	**L_under_vt**	**S_under_vt**	**L_under_vt**	**S_under_vt**	**L_under_vt**	**S_under_vt**
lopen	1.016 (4.757)***	0.759 (4.147)***	1.015 (4.785)***	0.738 (4.081)***	1.008 (4.7830***	0.742 (4.132)***	0.866 (3.883)***	0.818 (4.528)***
Linv_gdp	0.016 (0.062)	0.223 (1.015)	-0.010 (0.039)	0.297 (1.355)	0.007 (0.027)	0.272 (1.324)	0.116 (0.394)	0.254 (1.198)
Cpi	-0.041 (-3.971)***	-0.050 (-5.057)***	-0.042 (-4.204)***	-0.051 (-5.094)***	-0.042 (-4.215)***	-0.051 (-5.040)***	-0.046 (-4.155)***	-0.048 (-5.133)***
Large	0.011 (1.727)*		0.012 (1.782)*		0.012 (1.791)*		0.005 (0.689)	
Small		0.014 (0.658)		0.020 (1.062)		0.015 (0.947)		0.022 (1.644)*
Panel B: Short-run coefficient estimates								
Δlgdpt-1	0.251 (3.060)***	0.304 (3.834)***	0.248 (3.031)***	0.312 (4.069)***	0.251 (3.075)***	0.320 (4.155)***	0.280 (3.453)***	0.302 (3.937)***
Δcpi	-0.001 (-0.918)	-0.001 (-1.465)	-0.001 (-0.8664)	-0.001 (-1.744)*	-0.001 (-0.820)	-0.001 (-1.832)*	-0.001 (-1.241)	-0.001 (-1.392)
Δcpit-1	0.001 (4.634)***	0.001 (4.700)***	0.001 (4.577)***	0.001 (4.627)***	0.001 (4.617)***	0.001 (4.441)***	0.001 (4.615)***	0.001 (4.951)***
Δcpit-2	0.001 (3.660)***	0.001 (3.503)***	0.001 (3.696)***	0.001 (3.789)***	0.001 (3.675)***	0.001 (3.471)***	0.001 (3.533)***	0.001 (3.658)***
Δlarge				-0.001 (-1.254)				
Δsmall						-0.001 (-1.560)		
ECMt-1	-0.021 -7.755***	-0.019 (-7.442)***	-0.022 (-7.804)***	-0.019 (-7.714)***	-0.021 (-7.817)***	-0.019 (-7.507)***	-0.020 (-7.485)***	-0.020 (-7.793)***
Bounds test	9.569***	8.812***	9.690***	9.195***	9.732***	8.961***	8.913***	9.663***
LM test	1.309(0.274)	1.584(0.209)	1.726(0.182)	0.926(0.399)	2.017(0.138)	0.935(0.395)	1.764(0.176)	0.689(0.504)
White test	1.345(0.222)	1.576(0.131)	1.513(0.152)	1.484(0.155)	1.565(0.135)	1.540(0.135)	1.215(0.293)	0.911(0.518)
CUSUM	S	S	S	S	S	S	S	S
CUSUMQ	S	S	S	S	S	S	S	S

*; **; *** denote significance at 10%, 5% and 1% respectively

represents the Breusch-Godfrey Serial Correlation LM Test and ## the Heteroscedasticity White Test

For CUSUM and CUSUMQ: S is stable and U is unstable at a 5% level.

Accordingly, three sets of results are reported: equations that include the undervalued series alone (Table 4.6), overvaluation series alone (Table 4.8) and equations that include both series (Table 4.7). With regard to exchange rate undervaluations, the results presented in Table 4.6 indicate that the size of misalignment does indeed matter since exchange rate undervaluations below 10% have no meaningful impact on economic growth. This is because the coefficient for small undervaluation is not statistically significant for models where the threshold is less than 10% (the coefficient for small misalignment at a 10% level has a p-value of 0.1030). Coefficients for large exchange rate undervaluations from 3% to 7% are all positive and statistically significant, with the larger than 10% threshold not statistically significant. Models that have exchange rate overvaluation variables at all threshold levels are not satisfactory since the coefficients, although negative, are not statistically significant (see Table 4.8).

Table 4.7: Combined overvaluation and undervaluation series[32]

Misalignment thresholds								
Long-run coefficient estimates								
	Large	**Small**	**Large**	**Small**	**Large**	**Small**	**Large**	**Small**
	3%		**5%**		**7%**		**10%**	
Lopen	1.080 (4.587)***	1.485 (1.158)	1.011 (4.650)***	0.806 (4.520)***	0.993 (4.509)***	0.704 (3.778)	2.039 (1.787)*	0.761 (4.596)***
Linv_gdp	-0.155 (-0.538)	-3.551 -0.626)	-0.005 (-0.021)	0.270 (1.131)	0.025 (0.093)	0.322 (1.548)	-1.419 (-0.833)	0.365 (1.883)*
Cpi	-0.044 (-3.467)***	0.015 (0.272)	-0.041 (-4.037)***	-0.050 (-6.025)***	-0.042 (-3.917)***	-0.052 (-4.871)***	-0.009 (-0.321)	-0.051 -5.917)***
Under_V	0.016 (2.164)**	1.594 (0.706)	0.012 (1.776)*	0.011 (0.560)	0.011 (1.763)*	0.022 (1.174)	0.016 (1.062)	0.081 (3.382)***
Over_V	-0.005 (-0.573)	-0.529 (-0.566)	-0.001 (-0.090)	0.084 (2.031)**	-0.002 (-0.312)	-0.006 (-0.631)	0.255 (1.139)	-0.019 (-2.083)**
ECM_{t-1}	-0.018 -7.221***	-0.003 -5.877***	-0.021 -7.805***	-0.019- 7.860***	-0.021 -7.829***	-0.020 -7.560***	-0.009- 5.331***	-0.020 -7.894***
Bounds Test **LM test** **White test**	7.033*** 2.304(0.105) 0.987(0.466)	4.586*** 0.422(0.885) 1.270(0.205)	8.228*** 1.709(0.186) 1.362(0.208)	8.317*** 0.542(0.583) 1.040(0.421)	8.279*** 1.922(0.514) 1.451(0.168)	7.715*** 0.753(0.473) 1.381(0.193)	3.777** 1.657(0.124) 0.866(0.657)	8.385*** 0.010(0.989) 0.948(0.510)
CUSUM	S	S	S	S	S	S	S	S
CUSUMQ	S	S	S	S	S	S	S	S

*; **; *** denote significance at 10%, 5% and 1% respectively
[#] represents the Breusch-Godfrey Serial Correlation LM Test
[##] represents the Heteroscedasticity White Test
For CUSUM and CUSUMQ: S is stable and U is unstable

A combination of the threshold series in one equation produces interesting results especially for over- and undervaluation series with a maximum threshold of 10% (see results in Table 4.7). Generally, the findings are consistent with the other model specifications where small

[32] Short-run error correction coefficients results are not reported but can be provided on request.

undervaluations have a positive effect on economic growth but are not statistically significant, and the overvaluation impact is negative but insignificant. Interestingly, at the 10% maximum misalignment threshold level (i.e. overvaluation and undervaluation not exceeding 10%), the coefficient for undervaluation is positive and statistically significant (1% level) with the value for the overvaluation coefficient negative and statistically significant at a 5% level. The Wald test statistic also confirms that there is asymmetry between the two variables at a 1% confidence level. This confirms that thresholds do indeed matter in the analysis of the reaction of economic performance to exchange rate misalignment, so much so that ignoring it would render an analysis incomplete.

Table 4.8: Overvaluation series alone (different thresholds)

	Misalignment Thresholds							
	L_over_vt	**S_over_vt**	**L_over_vt**	**S_over_vt**	**L_over_vt**	**S_over_vt**	**L_over_vt**	**S_over_vt**
	3%		**5%**		**7%**		**10%**	
lopen	0.745 (3.206)***	0.839 (3.368)***	0.766 (4.030)***	0.834 (4.659)***	1.644 (1.524)	0.754 (3.879)***	1.734 (1.675)*	0.719 (3.763)***
Linv_gdp	0.091 (0.326)	0.202 (0.746)	0.212 (0.948)	0.220 (0.944)	-1.184 (-0.647)	0.224 (0.996)	-1.127 (-0.702)	0.250 (1.118)
Cpi	-0.055 (-3.893)***	-0.052 (-3.955)***	-0.050 (-4.756)***	-0.049 (-6.141)***	-0.020 (-0.551)	-0.050 (-4.510)***	-0.021 (-0.777)	-0.052 (-4.697)***
Large	-0.001 (-0.169)		-2.49E-05 (-0.003)		0.069 (0.944)		0.276 (1.124)	
Small		0.029 (0.465)		0.094 (2.594)**		-0.002 (-0.202)		-0.008 (-0.948)
Short-run[33]								
ECM$_{t-1}$	-0.015 -6.721***	-0.015 -5.839***	-0.019 -7.423***	-0.019 -7.798***	-0.007 -3.915***	-0.019 -7.428***	-0.008 -5.124***	-0.019 -7.522***
Bounds test	7.176***	5.390***	8.766***	9.654***	2.406	8.778	4.122**	9.003***
LM test	2.306(0.104)	0.760(0.638	1.705(0.186)	0.537(0.586)	1.171(0.328)	1.764(0.176)	1.661(0.122)	2.049(0.134)
White test	1.001(0.450)	1.283(0.221)	1.113(0.360)	1.046(0.413)	0.991(0.489)	1.279(0.256)	0.979(0.505)	1.181(0.314)

*; **; *** denote significance at 10%, 5% and 1% respectively
represents the Breusch-Godfrey Serial Correlation LM Test
represents the Heteroscedasticity White Test

4.7 EXCHANGE RATE MISALIGNMENT, VOLATILITY AND GROWTH

There is enough reason to believe that it might not just be exchange rate misalignment that influences growth, but misalignment together with another form of uncertainty represented by exchange rate volatility. The analysis was therefore extended further to ascertain if the results change if exchange rate volatility was considered as an additional determinant to misalignment for South African economic growth. This is on the premise that the positive effects of an undervalued

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[33] The short-run coefficient of the error correction model results is not reported since some of the lags are very long. These can be provided upon request.

exchange rate could be cancelled out by the risk as represented by exchange rate volatility, or that the negative effects of overvaluation are compounded by the concomitant volatility (Fang & Miller, 2007).

Table 4.9: Exchange rate misalignment, volatility[34] and growth

	Model 1 Mist & Volatility		Model 2 Volatility		Model 3 Under_v, Over_v & volatility	
	ARDL(2,0,0,3,0,0)		ARDL(2,0,0,3,0)		ARDL (2,0,0,3,0,0,0)	
Variable	coefficient	t-statistic	coefficient	t-statistic	coefficient	t-statistic
Panel A: Long-run coefficients						
lopen	0.951	4.530***	0.874	4.581***	1.023	5.025***
linv_gpd	0.114	0.475	0.191	0.917	0.037	0.149
cpi	-0.042	-4.327***	-0.045	-5.936***	-0.041	-4.425***
MISt	0.004	0.664	-	-		
Vol_t	-14.743	-0.605	-18.889	-0.849	-4.088	-0.159
Under_v					0.012	1.579
Over_v					-0.006	-0.765
constant	11.156	14.527***	11.141	15.082***	10.998	15.686***
Panel B: Short-run coefficients						
$\Delta lgdp_{t-1}$	0.257	3.114***	0.272	3.345***	0.248	3.056***
Δcpi	-0.001	-1.011	-0.001	-1.257	-0.001	-1.024
Δcpi_{t-1}	0.001	4.741***	0.001	4.828***	0.001	4.729***
Δcpi_{t-2}	0.001	3.658***	0.001	3.646**	0.001	3.734***
ECM_{t-1}	-0.022	-7.628***	-0.022	-7.559***	-0.023	-7.892***
Bounds Test	7.859***		9.092***		7.290***	
LM test	1.546(0.217)		1.969(0.144)		1.370(0.258)	
White Test	3.549(0.000)		2.638(0.001)		4.088(0.000)	
CUSUM	U		S		U	
CUSUMQ	S		S		S	

*; **; *** denote significance at 10%, 5% and 1% respectively
represents the Breusch-Godfrey Serial Correlation LM Test and ## the Heteroscedasticity White Test
For CUSUM and CUSUMQ: S is stable and U is unstable at a 5% level.

[34] The volatility measure for the REER is estimated via the GJR-GARCH (1,1) model as per Chapter 3.

The estimation procedure above was repeated, adding the variables of interest to the growth model. As a baseline model, a model was estimated where only volatility (estimated using the GJR-GARCH 1,1 model) was added to the economic performance equation (i.e. without exchange rate misalignment), and this was compared to two other specifications: one with misalignment (symmetric) and volatility, and another with overvaluation, undervaluation and volatility (results in Table 4.9 above.

Starting with exchange rate volatility on its own, the results (Table 4.8: Model 2) indicate that the long-run impact of exchange rate volatility on economic performance is negative, although the coefficient is not statistically significant. When volatility is considered together with a single misalignment series (Model 1), the results do not change as the coefficient for misalignment remains positive (and not statistically significant), whilst the coefficient for volatility is negative and also statistically insignificant. The same conclusion is reached on the asymmetric ARDL model with overvaluation and undervaluation inclusive of volatility. The coefficient for undervaluation remains positive, with undervaluation and volatility both negative, although all three are not statistically significant. The conclusion therefore is that no meaningful relationship could be found between exchange rate misalignment and volatility on South Africa's economic growth. Where the maximum 10% threshold level of misalignment is used together with volatility, the overvaluation and undervaluation variables have the correct signs and are statistically significant, but the volatility remains negative and insignificant. In summary, one can conclude from the results that there is an asymmetric impact of exchange rate misalignment on growth in South Africa, with exchange rate undervaluation of around 10% contributing positively to economic growth in the long run. Exchange rate volatility as measured by the GJR-GARCH (1,1) model has no meaningful impact on economic growth. The findings regarding volatility are against general expectations and what has been observed in most studies (e.g. Aghion *et a*l, 2009; Schnabl, 2007) where volatility negatively influences economic activity. A closer look at the results (Table 4.8 Models 1 & 3) shows that the models inclusive of both misalignment and volatility are unstable as the CUSUM and CUSUMQ statistics fall outside the 5% (between 2005Q4 and 2010Q4). As observed in chapter 3, a limitation about the volatility series used in the study is the fact that monthly data is applied to estimate volatility and further transformed to quarterly series and this raises the possibility of losing some of the volatility characteristics. With the model unstable, GARCH methods that take into account structural breaks in the series could be explored in an effort to improve the results.

4.8 CONCLUSION

In this essay the influence of exchange rate misalignment on economic output in South Africa was empirically evaluated using quarterly data from 1985 to 2014. The BEER method was applied to derive exchange rate misalignment episodes and these were used in an ARDL cointegration method to test for the asymmetric influence of exchange rate misalignment on economic growth. Results from the study provide evidence that economic performance in South Africa responds differently to exchange rate over- and undervaluation, with the latter supportive of economic growth in the country. The results also confirm that there are asymmetric effects of exchange rate misalignment on economic growth in South Africa, with exchange rate undervaluation of approximately 10% being positively correlated with economic growth. Although not statistically significant, the results also show that exchange rate overvaluation has a negative influence on economic performance. Lastly, REER volatility, as specified through a GJR-GARCH (1,1) model, is not found to have an influence on real GDP. The findings support calls for policy that maintains minimal exchange rate undervaluation in an effort to boost economic growth, whilst at the same time avoiding overvaluation. With historical undervaluation episodes in South Africa mainly being a result of shocks to the exchange rate, there could be an argument for the SARB to consider deliberately influencing the exchange rate towards a desired level that would boost exports.

Some limitations that should be noted from the study include the insignificance of the volatility variable, which could be attributed to the volatility modelling approach employed. Different GARCH models that either take into account long memory or structural breaks could be a worthy addition to this study. Although the study finds a positive link between exchange rate undervaluation and economic performance, the channel through which the relationship is transmitted is not yet clear.

The analysis is extended in the next chapter which looks at the influence of exchange rate misalignment and volatility on export performance since the export sector represents a possible channel through which exchange rate movements could affect economic growth. Such an analysis is important for the country since exports are regarded as a key potential driver of economic growth from the various policy documents developed by the government, e.g. the National Development Plan..

Appendix 1

Table 4.9 - Descriptive Statistics for Chapter 4

	LGDP	LOPEN	LINV_GDP	CPI	MIS___	UNDER_VAL	OVER_VAL
Mean	14.52172	3.931725	2.915623	8.690517	-0.025811	-2.474637	2.448826
Median	14.46619	3.932805	2.928524	7.600000	0.528437	0.000000	0.528437
Maximum	14.91487	4.333361	3.202746	25.20000	13.79928	0.000000	13.79928
Minimum	14.21560	3.589059	2.721295	-2.500000	-22.09738	-22.09738	0.000000
Std. Dev.	0.229120	0.170476	0.126463	5.247376	6.600465	4.478108	3.359670
Skewness	0.346920	-0.024697	0.253039	0.483255	-0.795240	-2.374858	1.263521
Kurtosis	1.639110	2.411569	2.077830	2.735867	3.999324	8.325969	3.510310
Jarque-Bera	11.27828	1.685342	5.348141	4.852222	17.05334	246.1411	32.12407
Probability	0.003556	0.430559	0.068971	0.088380	0.000198	0.000000	0.000000
Sum	1684.519	456.0801	338.2123	1008.100	-2.994086	-287.0579	284.0638
Sum Sq. Dev.	6.037021	3.342151	1.839182	3166.520	5010.106	2306.147	1298.049
Observations	116	116	116	116	116	116	116

Table 4.10: Pairwise Correlations – Chapter 4 Variables

Covariance Analysis: Ordinary
Date: 01/11/18 Time: 06:24
Sample: 1985Q3 2014Q2
Included observations: 116
Balanced sample (listwise missing value deletion)

Correlation t-Statistic Probability	LGDP	LOPEN	LINV_GDP	CPI	UNDER_VAL	OVER_VAL
LGDP	1.000000 ----- -----					
LOPEN	0.797843 14.13025 0.0000	1.000000 ----- -----				
LINV_GDP	0.117218 1.260229 0.2102	0.309038 3.469456 0.0007	1.000000 ----- -----			
CPI	-0.529648 -6.667039 0.0000	-0.224888 -2.464267 0.0152	0.433045 5.129572 0.0000	1.000000 ----- -----		
UNDER_VAL	-0.097713 -1.048302 0.2967	-0.414360 -4.861111 0.0000	-0.059880 -0.640489 0.5231	-0.182438 -1.981158 0.0500	1.000000 ----- -----	
OVER_VAL	0.085222 0.913245 0.3630	-0.068109 -0.728894 0.4676	-0.155562 -1.681420 0.0954	-0.341349 -3.877502 0.0002	0.406292 4.747518 0.0000	1.000000 ----- -----

Table 4.11: Granger Causality test results for Baseline Asymmetry Model

Null Hypothesis:	Obs	F-Statistic	Prob.
DLGDP does not Granger Cause ECT	113	0.15823	0.8539
ECT does not Granger Cause DLGDP		4.27343	0.0164
OVER_VAL does not Granger Cause LGDP	115	3.03964	0.0519
LGDP does not Granger Cause OVER_VAL		0.59861	0.5514
UNDER_VAL does not Granger Cause LGDP	115	3.22229	0.0437
LGDP does not Granger Cause UNDER_VAL		0.69674	0.5004

DLGDP is ΔLGDP; ECT is the error correction term,

Over_val and Under_val overvaluation and undervaluation respectively

CHAPTER 5:

REAL EFFECTIVE EXCHANGE RATE MISALIGNMENT, VOLATILITY AND EXPORTS: THE CASE OF SOUTH AFRICA

5.1 INTRODUCTION

There is a common proposition in recent literature (e.g. Rodrik, 2008a; Nouira, Plane & Sekkat, 2011; Schroder, 2012; Sekkat, 2016) that proactive exchange rate policies centred around exchange rate disequilibria and deliberate currency undervaluation can foster economic growth through higher exports. Elbadawi (2005) states that the phenomenal economic transformation of several developing nations (especially in East Asia) observed in the past few decades could be attributed to export-orientated development strategies. It has also been noted in previous studies (e.g. Nabli & Veganzones-Varoudakis, 2004; Sekkat & Varoudakis, 2000) that countries that are seen to have avoided currency overvaluation have successfully promoted manufactured exports. Given that the exchange rate is an indicator of international competitiveness, its value as driven by global or local macroeconomic developments and its volatility becomes a potential contributing factor to the performance of the export sector. Faced with the challenges of anaemic economic growth rates, high unemployment and poverty levels, exchange rate movements therefore become a critical area of interest for countries such as South Africa.

As a small open economy with a floating exchange rate and an outward-looking trade policy (see Takaendesa *et al.*, 2006; Sekantsi, 2011), exchange rate movements have the potential to influence economic activity in South Africa given the importance of exports as an economic growth driver. Edwards and Garlick (2008) confirm the central role played by the value of the rand in public discussions on trade and trade policy in the country, with labour organisations mainly calling for a policy that facilitates exchange rate depreciation. This is based on the premise that a weaker currency would boost export competitiveness and diversification, protect local industries and improve the trade balance. From a policy perspective, export promotion (especially non-primary goods) has been at the centre of government policy as a driver of economic growth since the early 1970s (Rangasamy, 2009). The latest South African economic policy initiative the National Development Plan 2030 (Economic Development Department (2011) indicates a targeted export volume growth of 6% per year as the key driver of economic growth. This is in line with other policy proclamations e.g. the New Growth Path (2011) which called for a monetary policy stance that supports a more competitive exchange rate, and the Industrial Policy Action Plan 2012/13–2014/15, which proclaims that efforts to intensify export expansion especially to the rest of the African continent is fundamental for growth. Previous policies, including GEAR (Growth Employment and Redistribution) have also given credence to the need for a competitive exchange rate, whilst the ASGISA initiative (Accelerated and Shared Growth Initiative in South Africa) raised concerns about exchange rate volatility as an impediment to growth (Edwards & Garlick, 2008).

Although the link between exports and the exchange is widely acknowledged in South Africa at the policy level, there is limited empirical evidence to back such assertions. Performance of the export sector has not been satisfactory, with the World Bank (2014) stating that the country's export sector is underperforming and lagging that of its peers (BRICS countries and other emerging markets including Chile, Columbia, Turkey and Thailand: nations with similar populations, incomes and export baskets). Edwards and Alves (2006) also note that despite government policies that seek to generate export growth, the performance of the sector (especially manufacturing) has not been good enough to match experiences of export-led growth booms in other East-Asian nations (see also Fowkes, Loewald and Marinkov, 2016). With the key policy objective being to grow exports and the exchange rate an indicator of international competitiveness, the key policy question becomes whether South Africa can use the exchange rate to drive export performance. This is worth considering given the success seen in some Asian countries and the empirical literature that appears to support such an observation. It is well noted by Todani and Munyama (2005) that the link between exports and the exchange rate in South Africa is characterised by conflicting views with no convincing empirical evidence to back any meaningful relationship. This is confirmed by studies including Edwards and Garlick (2008), who observed that there is considerable scope for further research in this area, and Schaling and Kabundi (2014), who recently stated that the debate in South Africa on the pass-through effects of rand depreciation on either growth and inflation remains “alive and well”. This study seeks to provide more empirical evidence on the link between exports and exchange rate behaviour in the country by concentrating on exchange rate misalignment and the possible asymmetric impact on exports. In addition to aggregate exports, the study considers the reaction of key export sectors (manufacturing, mining and agriculture) to exchange rate misalignment occurrences. These sectors are considered because they are the possible major drivers of employment creation and economic growth in South Africa. Edwards and Garlick (2008) note that there is reason to believe that different sectors will react differently to foreign exchange rate movements since, for example, resource-rich countries (such as South Africa) could be victims of the Dutch Disease effect whereby a commodity boom would cause non-commodity exports to decline.

This essay differs from previous studies in various ways. First, this essay's focus is on neither the influence of just the level of the exchange rate nor its volatility as per previous studies (e.g. Anand, Perrelli and Zhang, 2016; Rangasamy, 2009; Fowkes *et al.*, 2016) but the impact of REER misalignment on exports, with misalignment defined as deviation of the exchange rate from its equilibrium level. Second, this study further investigates as to whether export performance differs between episodes of exchange rate undervaluation compared to overvaluation periods. It is hypothesised that an undervalued exchange rate will support exports whilst an overvalued currency would be harmful to exports. Affirmation of a positive impact of undervaluation on exports could render exchange management a possible policy instrument for growth promotion. Third, the study pays attention to the likelihood that such misalignment effects might be nonlinear (i.e. the impact depends on the size of the misalignment). Most prior studies (e.g. Cheung & Sengupta, 2013; Sekkat & Varoudakis, 2000; Ahmad, Mohd & Masron, 2010) have imposed a symmetrical relationship in the response of exports to exchange rate movements. The approach employed is in line with a new strand in the literature that focuses on asymmetry in the pass-through of exchange rates to economic variables (e.g. Karoro *et al.*, 2009; El Bejaoui, 2013; Bussière, 2013; Sekkat, 2016). Finally, given that, both exchange rate misalignment and volatility represent uncertainties that can influence the behaviour of exporters, this study seeks to ascertain whether a combination of these factors is important when one studies the influence of the exchange rate on South African exports. To the best of the author's knowledge, only a limited number of studies have followed this approach, with the author having no knowledge of such a study specifically focusing on the asymmetric and nonlinear reaction of exports to exchange rate misalignment in South Africa. This study therefore aims to fill the gap in the literature by addressing both the asymmetry and hysteresis in the underlying long-run relationship between South African exports and exchange rate misalignment occurrences.

The rest of the chapter is structured as follows: Sections 5.2 and 5.3 look at the theoretical and empirical literature whilst Section 5.4 covers the historical trajectory of the exchange rate and exports in South Africa. The methodology in presented in 5.5. Section 5.6 is devoted to the results and Section 5.7 provides a conclusion.

5.2 THEORETICAL FRAMEWORK

The theoretical framework underpinning this study can be broken down into two key components: 1) the link between exchange rate movements and exports (including the asymmetry aspects thereof and volatility), and 2) the nonlinear reaction of exports to exchange rate movements (exchange rate hysteresis). On the first component, there is a broad consensus on the assertion that economic policies boosting exports have a positive effect on economic growth (Eichengreen & Gupta, 2012). According to Eichengreen (2007), the literature on export-led growth is fundamentally about the benefits realisable from making the prices of exportables high enough (through the exchange rate) such that they are sufficiently attractive to shift resources to their production. The theoretical link between a country's exports and the exchange rate can therefore be explained by the fact that the exchange rate is a relative price indicator in the global markets and thus has an influence on a country's competitiveness in international markets (Poonyth & Van Zyl, 2000). Fundamentally, undervaluation of a country's currency results in a price decrease in the nation's products in international markets which should theoretically increase the quantity of exports. Such developments give domestic firms incentives to export, which should have a positive effect on economic growth in the long run.

With the marginal productivity of labour tending to be higher in the tradable sectors relative to other sectors (e.g. the primary sector), the exchange rate facilitates the efficient allocation of resources in the economy thus promoting further investments and growth (Eichengreen & Gupta, 2012). Nouira *et al*. (2011) further state that demand for manufactured products (for export purposes) rises with income compared to primary goods such that countries which target manufactured exports have higher prospects for growth. It is hence argued by Rodrik (2008a) that the real exchange rate as a relative price of non-tradables to tradables appears to play a key role in the convergence of developing country to developed country incomes. Within this context, it is also important to note that persistent exchange rate overvaluation would increase the foreign price of a country's exports thus hurting the competitiveness of domestic firms in the tradable sector and hence negatively affecting economic growth (Razin & Collins, 1997; Nabli & Veganzones-Varoudakis, 2004). Bhalla (2008) states that persistent exchange rate overvaluation can lead to factor misallocations, efficiency losses and ultimately lower economic growth. This is also a result of the fact that productivity improvements in the economy tend to be concentrated on the export or import-competing sectors (Cottani, Cavallo and Khan, 1990). Edwards and Garlick (2008) use a demand and supply framework to illustrate that the elasticity of export demand and supply determine the responsiveness of exports to exchange rate depreciation.

The main theoretical proposition is that overvalued exchange rates hurt relative export prices whilst an undervalued currency boosts export competitiveness, hence the influence on export volumes and economic growth. Since the fundamental driver of export performance is demand, the price elasticity of demand for exports is a key determinant of export performance, together with the market structure within which an exporting firm operates and its entire production function. It is well noted by Campa (2004) that for one to understand the reaction of exports to exchange rate movements on the balance of payments, one needs to comprehend firm level decisions since aggregate exports are made up of total individual firm decisions. The premise is that exporting firms would react to price signals generated by the market (including movements in exchange rates).

This study uses the theoretical model of Caballero and Corbo (1989) to illustrate the response of exports to exchange rate misalignment at firm level. According to the model[35] (Sidek, Bin Yusoff, Ghani & Duasa, 2011), an export-oriented firm would face the following demand curve:

$$X^d(t) = A_1(t)\left[\frac{Px(t)}{Pw(t)}\right]^{-\rho} \qquad \ldots(5.1)$$

with X^d representing export demand, Px and Pw denoting the export price and world price indices, A_1 an arbitrary time function and ρ the price elasticity of demand. The production function facing the firm is given by:

$$X^s(t) = A_2(t)L(t)^{\alpha}K(t)^{1-\alpha} \qquad \ldots(5.2)$$

[35] Important to note is that it is not countries that export but firms, so an analysis of decision making at firm level becomes important. See Caballero and Corbo (1989) and Sidek *et al*. (2011) for more detail on the model specification.

where X^s is export supply, L(*t*) and K(*t*) the labour and capital used in production (inputs) and A_2 an arbitrary function of time. α represents labour share of output with 1- α the capital share of output. ER(*t*) and W(*t*) are the real exchange rate (nominal exchange rate deflated by consumer prices) and real wages (also nominal wages deflated by the consumer price index) and both variables are assumed as exogenous to the firm (Caballero & Corbo, 1989). Given the above production function, an exporting firm will maximise profits π (K, *t*), as follows:

$$\pi\,(K, t) = \max_{L(t)} ER(t)Pw(t)A_1(t)^{1/\rho}X(t)^{\mu}W(t)L(t) \qquad \ldots(5.3)$$

where (μ= ρ-1)/ρ is an inverse index of monopoly power. If one assumes constant wages such that uncertainly is only realised through exchange rate movements, the profit function of the exporter is reduced to a function of capital stock and the real exchange rate and the remaining variables become a deterministic function of time B(*t*) such that:

$$\pi\,[(K(t), t] = B(t)K(t)^{\Theta 1}ER(t)^{\Theta 2} \qquad \ldots(5.4)$$

with Θ_1 and with Θ_2 denoting industry specific constraints where

$$\Theta_1 = \frac{\mu(1-\alpha)}{1-\alpha\mu} < 1 \text{ and } \Theta_2 = \frac{1}{1-\alpha\mu} > 1 \qquad \ldots(5.5)$$

The exchange rate ER(*t*) therefore affects an exporting firm's profits mainly through its effects on the demand for exports in µ and the production costs as summarised in α. Differentiating Equation 5.4 gives

$$\frac{\partial\pi(t)/\partial ER(t)}{\pi(t)/ER(t)} = \Theta_2 \qquad \ldots(5.6)$$

Given that $\Theta_1 < 1$ and $\Theta_2 > 1$, Equation 5.6 under strict conditions advocates that an exporter's profit would increase in cases of exchange rate depreciation or undervaluation with profits falling when the exchange rate appreciates or gets overvalued (Sidek *et al.*, 2011). A weak currency would therefore provide an incentive for firms to export more with overvalued exchange rates having the opposite effect.

In addition to the differentiated effects depending upon whether the exchange rate is undervalued or overvalued, the influence of exchange rate movements on exports could also depend on whether the misalignment is large or small (exchange rate hysteresis) such that both the sign and size of misalignment are worth considering (Béreau *et al.*, 2012). This argument is valid for South Africa since the country's exchange rate is known to be prone to significant bouts of volatility. Verheyen (2013) states that such nonlinearities in the reaction of exports to exchange rate movements should be expected since firms will not react to every move in the exchange rate. For instance, when faced with an episode of exchange rate overvaluation, an exporter might absorb some of the price effects into his/her margins in order to protect market share (pricing to market strategy) such that the influence on the volume of exports is not as expected. The effects of an overvalued currency would therefore be absorbed in the profit margin thus temporarily reducing the firm's return on capital. Faced with a depreciating exchange rate and favourable price competitiveness (also as a result of exchange rate undervaluation), an exporter's volumes might also not fully increase because of low elasticity of demand for such export products in the international markets. A case in point is the subdued global economic growth environment experienced after the global financial crisis of 2007/2008 which suppressed global trade volumes such that demand for goods was suppressed. The market structure (degree of competition) within which an exporter operates would be the key determinant in the firm's pricing to market strategy and decision to respond to exchange rate movements.

The theoretical literature on exchange rate trends and firm decisions places assumptions on the fact that in order to enter external markets, a non-exporter must incur entry costs that are non-refundable (sunk costs) and these costs could include setting up of distribution networks, marketing and compliance with the foreign markets regulations (Campa, 2004). This implies that an exchange rate must be undervalued beyond a certain point or threshold to attract new entrants into the export market such that minimal exchange rate movements would not be significant to attract new entrants. Should expected profits from entering the export market (exporting) exceed the sunk costs, the decision is to invest thus bringing in new entrants and increasing the volume of exports. Regarding the decision to leave the market, a firm will stay in the market as long as expected gross profits remain positive despite unfavourable exchange rate (overvalued currency) movements since there are also costs involved in searching and switching to new markets. Firms will therefore exit the export markets once the exchange rate is overvalued beyond another threshold level. Such behaviour leads to the assertion that there are 'bands of inaction' where exporters do not respond to exchange rate movements until such time as the movements exceed certain thresholds to make it meaningful to induce firm behaviour (see Belke & Kronen, 2016; Denadai & Teles, 2016). It is of course worth noting that single firms will have different threshold levels based on their cost structures and level of productivity but in general, small exchange rate movements are not expected to change firm behaviour compared to larger exchange rate movements (the so-called exchange rate hysteresis).

Bussière (2013) observes that other factors driving asymmetry and nonlinearities in the response of exports to exchange rate movements include price and quantity rigidities. Prices are noted to be generally sticky going down, especially in the short run. Given an undervalued exchange rate, exporting industries benefiting from price competitiveness (all else remaining constant) can increase the quantity of exports whilst keeping their prices unchanged in domestic currency terms. On the other hand, if there is either lack of capacity to increase production or the presence of adjustment costs, this would make it challenging for the exporters to increase production, thus they may resort to increasing prices instead (Bussière, 2013). On the other hand, an overvalued currency should theoretically make exports less competitive in international markets, thus undermining a country's export capacity. Faced with persistent currency appreciation, exporters could lower their prices in an effort to maintain market share but their ability to reduce prices is limited since this could result in negative margins (or losses). Confronted with the downward price rigidity, exporters would therefore resort to reducing the quantity they sell abroad. Upward quantity and downward price rigidities therefore ensure that the response of exports to exchange rate movements (overvaluations and undervaluations) would become asymmetric and nonlinear, with the final impact depending on a combination of factors that also include the elasticity of exports and capacity constraints.

On volatility and exports, the theoretical underpinnings for such a relationship originates from firm-level decision making under uncertainty and normally assumes a negative relationship between exchange rate volatility and trade (Aubion & Ruta, 2011). Such a theoretical framework (attributed to authors such as Clark (1973), and Hooper and Kohlhagen (1978)), is based on the premise that the expected profits (in domestic currency) of an exporting firm that operates under perfectly competitive market conditions and is paid in foreign currency, are affected by exchange rate movements which are unpredictable. Since exchange rate volatility is defined as risk emanating from unexpected exchange rate movements, the argument is that the uncertainty regarding future exchange rates directly translates into uncertainties about future receipts and profits – for risk-averse firms, this raises the marginal cost of production to the detriment of output and exports (IMF, 2004). Higher exchange rate volatility therefore theoretically leads to higher costs for risk-averse exporters and to less foreign trade. Whether this negative relationship holds is a different issue since factors such as the availability of hedging instruments, other market structures (e.g. oligopolistic or monopolistic), invoicing currency and input costs in foreign currency could influence the nature of the relationship between volatility and exports; hence the empirical literature is mixed in terms of such a relationship (Fang *et al.*, 2006).

In summary, the influence of exchange rate movements on exports (asymmetries and nonlinearities) could be explained by a combination of menu and switching costs, price and quantity rigidities, capacity constraints, hedging strategies (where there are developed financial markets), pricing to market strategies (influenced by market structure) and the duration and persistence of the exchange rate movements. Given the above theoretical observations, the impact of exchange rate misalignment on exports thus becomes an empirical question which needs to be investigated. The mission to capture the differences between the response of exports to exchange rate overvaluation and undervaluation episodes remains an interesting phenomenon since most studies have either assumed symmetry (Couharde & Sallenave, 2013) or paid attention to either appreciation or depreciation and not overvaluation versus undervaluation effects.

5.3 LITERATURE

From an empirical point of view, there is a great body of literature focusing on the link between exports and the exchange rate. For example, work from Sekkat and Varoudakis (2000), Bhalla (2008), Golub and Ceglowski (2002), Edwards and Garlick (2008), Nabli and Veganzones-Varoudakis (2004) and Nouira *et al.* (2011) all suggest that exchange rate behaviour (through appreciations versus depreciations, misalignment or volatility thereof) influences a country's export performance. Another strand in the global literature mainly considers the ERPT to import and/or export prices (e.g. Karoro *et al.*, 2009; Narayan & Narayan, 2010; Bussière, 2013). It is worth noting that most South Africa specific studies focus on either the impact of exchange rate volatility on exports (e.g. Sekantsi, 2011; Todani & Munyama, 2005; Takaendesa *et al.*, 2005; Fowkes *et al.*, 2016) or the level of the exchange rate and export performance or trade flows (e.g. Edwards & Garlick, 2008; Golub & Ceglowski, 2002; Poonyth & Van Zyl, 2000).

Table 5.1: Selected studies on exchange rate misalignment and exports

Author(s)	Country	Misalignment estimation approach	Methodology	Asymmetry and nonlinearity considered	Conclusion
Pick and Vollrath (1994)	10 selected countries	FEER (Edwards)	OLS (panel)	No	Exchange rate misalignment, especially overvaluation, has a negative impact on agricultural exports
Sekkat and Varoudakis (2000)	Sub-Saharan countries	Black market premium, PPP & BEER	Panel approach (Fixed effects)	No	Exchange rate misalignment hinders exports
Nabli and Veganzones-Varoudakis (2004)	MENA countries	BEER	ECM	No	Overvaluation dampens exports competitiveness
Bouoiyour and Rey (2005)	Morocco	NATREX	VECM	No	Misalignment affects trade flows with overvaluation leading to deterioration in trade balance
Mtonga (2006)	South Africa	BEER	VECM	No	Exchange rate overvaluation has negative consequences for export competitiveness
Jongwanich (2009)	Eight Asian countries	BEER	GSM Procedure	No	Exchange rate misalignment has a negative impact on exports
Nouira *et al.* (2011)	Several developing countries	BEER	Panel Granger Causality tests	No	Countries that allowed exchange rate undervaluation enhanced manufactured exports
Rajan and Subramanian (2011)	Several countries	PPP	Panel	No	More foreign aid undermines export competitiveness through exchange rate appreciation and misalignment
Freund & Pierola (2012)	Several Countries	PPP	Panel approach	No	Significant exchange rate depreciation and undervaluation precedes export growth
Sekkat (2016)	Several countries	PPP & BEER	Panel Granger Causality Tests	Yes	Undervaluation supports the share of manufactured exports
Wondemu and Potts (2016)	Tanzania and Ethiopia	BEER	GMM	Yes	Undervalued exchange rates have boosted exports with overvaluation harming exports
Fowkes *et al.*(2016)	South Africa	BEER	Correlation Analysis	Yes	Currency undervaluation appears to favour exports

It can also be observed from recent studies (e.g. Béreau *et al.*, 2012; Sekkat, 2016) that the literature on exchange rate misalignment and the asymmetric and nonlinear impact on economic indicators (e.g. economic growth or exports) is scant. According to Verheyen (2013), despite the long history of the estimation of export demand equations, the subject of nonlinearity in the response of exports to exchange rate changes has been neglected despite its importance. The literature relevant for this study can therefore be grouped into three categories. One category includes studies that consider the effects of exchange rate misalignment (various countries) on exports including possible asymmetric effects (Table 5.1). The other category has studies that have considered the effects of exchange rate movements on exports or the trade balance in South Africa (Table 5.2 below).Lastly, there are studies that have measured the response of exports to exchange rate volatility in South Africa (Table 5.3).

On the subject of exchange rate misalignment and the reaction of exports to such exchange rate behaviour, Pick and Vollrath (1994) assessed the impact of exchange rate misalignment on agricultural exports in ten selected developing nations. Their study finds that misaligned exchange rates, especially overvaluations, hurt agricultural exports, thus highlighting the need for macroeconomic policy that aims to limit exchange rate overvaluation. Sekkat and Varoudakis (2000) used data from 1970 to 1992 to indicate that real exchange rate misalignment exerts a negative influence on manufactured exports in sub-Saharan Africa. Their study calls for an appropriate exchange rate policy that seeks to limit exchange rate volatility and use misalignment as an enabler for export competitiveness. Nabli and Veganzones-Varoudakis (2004) model export performance for Middle East and North African (MENA) countries as a function of variables that include exchange rate volatility and misalignment. Applying data covering the period 1970 to 1999, the study indicates that over this period, the currencies of the MENA countries were characterised by notable overvaluation, which in turn hampered the competitiveness of their exports, especially manufactured goods.

Nouira *et al.* (2011) use data from a sample of 52 countries from Africa, Asia and Latin America to investigate whether some countries opt for a proactive exchange rate policy that seeks to support manufactured exports. According to their results, several countries over the period 1991 to 2005 used exchange rate undervaluation as a means to support price competitiveness of manufactured exports. A study by Freund and Pierola (2012) focuses on export surges (explained as sustained upsurges in manufacturing exports for at least seven years) to indicate that in a sample of 92 countries (including South Africa) studied over the period 1980 and 2006, good export performance (especially for developing countries) was preceded by exchange rate depreciation and a move from over- to undervaluation. A conclusion to the effect that an exchange rate has a role to play in encouraging exports is made since exchange rate depreciation could be used to correct for distortions that encourage suboptimal entry into new markets (Freund & Pierola, 2012).

Amongst the limited studies focusing on African countries, Wondemu and Potts (2016) seek to understand the influence of the real exchange rate and its misalignment on export diversification and supply in Tanzania and Ethiopia. They also conclude that exports react positively to an undervalued exchange rate as opposed to overvaluation. Noting the differences in exchange rate policy between the two countries, Tanzania – which was found to have maintained an undervalued currency – performed better in exports than Ethiopia. Wandemu and Potts (2016) note however that the side effects of such a policy had been high inflation experienced over the period for Tanzania. Rajan and Subramanian (2016) take a somewhat different approach and study the effects of foreign aid on economic growth in several aid-receiving developing countries due to the lack of robust evidence in support of a strong correlation between aid and growth of poor countries. Their results indicate that the failure of aid to boost economic growth is due to its negative effects on the tradables sector (i.e. higher inflows of aid undermine the competitiveness of the export sector) and the transmission channel through an appreciated and overvalued exchange rate. From a policy perspective they recommend that policy should focus on the absorptive capacity of aid in the receiving countries such that the negative, undesired effects from exchange rate overvaluation are mitigated. Other studies that confirm the positive response of exports to exchange rate undervaluation include Jongwanich (2009) – nine Asian nations, Bouoiyour and Rey (2005) – Morocco, and Haddad and Pancaro (2010) – several countries. Although looking at misalignment and exports by using only one series of misalignment in their export demand functions, the studies mentioned above neglected the possible existence of asymmetry and nonlinearities when modelling the response of exports to exchange rate undervaluation and overvaluation episodes.

Empirical studies specific to South Africa that have considered exchange rate misalignment and trade include Mtonga (2006) who applied a VECM in a BEER framework to model the rand's equilibrium level and measure the extent of misalignment using data from 1970 to 2003. The study finds that the rand was undervalued by an average of 10% in the periods 1994 to 1996 and 1998, and overvalued by about 15% between 2002 and 2003. A conclusion by Mtonga (2006) was that exchange rate misalignment has consequences for South African export competitiveness in the international markets, but does not model export demand to reach such a conclusion. Most recently, Fowkes *et al.* (2016) focus on the disappointing performance of South Africa's exports and hence explore the influence of the level of the exchange rate and its volatility on both GDP and exports. Applying two measures of exchange rate misalignment – one based on the BEER model of De Jager (2012) and the other based on Rodrik's (2008a) PPP undervaluation index – their results appear to suggest that there is a link between exports and the exchange rate with currency undervaluation favouring exports. By applying correlation analysis to reach this conclusion, the results from the study do not appear sufficiently robust as the asymmetric and nonlinear influence of over- versus undervaluation on exports is ignored. South African-focused studies indicated above have therefore mainly considered the response of exports to exchange rate movements (appreciation and depreciation) without necessarily paying attention to whether the exchange rate was misaligned or not, with the studies largely ignoring the possibility of asymmetry and nonlinearity in the export demand functions estimated.

Table 5.2: Studies on exchange rates and exports in South Africa

Author(s)	Period	Method	Exchange rate measure	Interest variable	Asymmetry and nonlinearity considered	Conclusion
Smal (1996)	1985-1994	OLS	Nominal exchange rate	Imports and exports	No	Exchange rate depreciation can help export growth
Poonyth and van Zyl (2000)	1991-1999	ECM	Real exchange rate	Agricultural exports	No	Appreciation of exchange rate hurts exports
Golub and Ceglowski (2002)	1970-1998	OLS	REER	Manufactured exports and imports	No	Exports react positively to competitive REER
Edwards and Alves (2006)	1970-2002	GMM	Real exchange rate	Manufactured exports	No	Exports react positively to exchange rate depreciation
Edwards and Lawrence (2006)	1970-2005	VECM	REER	Imports and exports	No	REER depreciation promotes exports
Edwards and Garlick (2008)	1970-2005	Theoretical & empirical review	REER	Exports and Imports	No	Exchange rate depreciation enhances export performance
Bahmani-Oskooee and Gelan (2012)	1971-2008	ARDL	REER	Trade Balance (J-curve effect)	No	No short-run effects of exchange rate depreciation with visible long-run effects
Ncube and Ndou (2013)	1983-2010	VAR	REER	Trade Balance	No	Exchange rate appreciation shock worsens trade balance
Schaling and Kabundi (2014)	1994-2011	VECM	REER	Trade Balance (J-Curve Effect)	No	REER depreciation improves trade balance in the long-run
Ziramba and Chifamba (2014)	1975-2011	ARDL	REER	Trade Balance (J-curve effect)	No	Results do not support existence of J-curve effect
Anand *et al.* (2016)	2010-2014	Panel ARDL	REER	Sectorial Exports	No	REER depreciation boosts exports, especially manufacturing

Studies specific to the asymmetric impact of exchange rate misalignment on export performance are quite limited. Sekkat (2016) is amongst the few, and applies data from Asia, Africa and Latin American countries (1985-2009) in a panel study to explore the circumstances under which exchange rate misalignment (over- and undervaluation) could influence export diversification. Noting the lack of consensus from empirical evidence on the impact of misalignment on export diversification, Sekkat (2016) finds some evidence to indicate that undervaluation supports the share of manufactured exports whilst both directions of misalignment (under and overvaluation) had no meaningful impact on export diversification within manufactured goods. Sekkat (2016) also observes that the empirical evidence thus far has failed to establish a concise causal effect of exchange rate misalignment on exports. Verheyen (2013) employs a nonlinear ARDL method to investigate whether exports to the US from 12 EMU (European Monetary Union) countries react to exchange rate changes in a nonlinear manner. Results from the study provide evidence that exports respond strongly to exchange rate depreciations as opposed to appreciations, with limited evidence in support of hysteresis (i.e. difference in the impact of small versus large exchange rate movements). Sidek (2011) use a Threshold Autoregressive Model (TAR) to estimate thresholds within which a misaligned exchange rate negatively affects exports in Malaysia, and concludes that 8.8% is the crucial level within which an overvalued exchange rate leads to a decline in exports.

In the context of South African-specific literature, one of the earliest studies is Poonyth and Van Zyl (2000) which studied the relationship between the real exchange rate and agricultural exports. Applying an Error Correction Model (ECM), they confirm existence of a unidirectional causal flow from the real exchange rate to exports which helps them to conclude that a SARB policy that causes the exchange rate to appreciate would hurt agriculture exports. In a related study, Golub and Ceglowski (2002) focus on the manufacturing sector and used OLS regressions to indicate that South Africa's exports respond strongly to exchange rate movements as represented by different specifications of a competitive REER. The authors conclude that a competitive exchange rate and strong global economic growth are key to the success of South Africa's export-led growth strategy. In a paper that analyses the country's export structure and volumes, Edwards and Alves (2006) find that South African exporters respond to policies and environments that improve the profitability of exports, with manufactured exports responding positively to the real exchange rate's depreciation in the 1990s.

Reviewing empirical literature on exchange rate and exports and imports in South Africa, Edwards and Garlick (2008) find that although real exchange rate depreciation can raise export volumes, nominal depreciation in the exchange rate would not have a long-term effect on trade flows if the currency decline is accompanied by higher inflation and wage escalations. Their study puts an emphasis on other factors that can positively drive exports including labour productivity and adequate infrastructure as key to supporting international trade. In a more recent paper, Anand *et al.* (2016) make an observation that in the aftermath of the 2007/2008 global financial crisis, South

Africa's export performance was not good despite prolonged exchange rate depreciation. Using firm-level data, the authors indicate that structural constraints in South Africa have made it difficult for the country to benefit from advantages brought about by a weaker exchange rate. This conclusion is also in line with the observations from the World Bank (2014) who found that supply-side constraints associated with infrastructure bottlenecks (e.g. electricity supply, industrial action and rising labour costs) makes it difficult for South African exporting firms to benefit fully from exchange rate deprecation.

The mixed results from previous studies pertaining to direction, extent and duration of foreign exchange rate movements on exports motivated Rowbotham, Saville and Mbululu (2014) to study whether price competitiveness resulting from exchange rate depreciation in nine efficiency-driven countries (including South Africa) helps achieve export growth. Their results are contrary to popular findings since they find that good export performance was associated with appreciated exchange rates. Other strands in the South African literature have focused on the impact of exchange rate depreciation on the trade balance (the J-curve phenomenon) without specifically targeting exports. These studies include Schaling and Kabundi (2014) who use 1994-2011 data to confirm the existence of the J-curve effect in South Africa (i.e. currency depreciation or devaluation improves the trade balance in the long run after a short-run deterioration). A similar study by Ziramba and Chifamba (2014) who use an ARDL model with data from 1975 to 2011 fails to confirm the existence of the J-curve effect in South Africa. Noting the limited attention that the literature has paid to African countries, Bahmani-Oskooee and Gelan (2012) tested the J-curve phenomenon for eight African countries including South Africa. Their results are mixed with limited support for the J-curve effect. Although the study finds no support for the J-curve effect in the short run, real exchange rate depreciation was found to yield a favourable long-run impact on the trade balance for only three countries (Egypt, Nigeria and South Africa). The authors also note that import and export volumes could not be responding adequately to exchange rate movements due to inelasticity issues.

Table 5.3: Selected studies on applied exchange rate volatility of the rand

Author(s)	Nature of study	Volatility measures	Conclusion
Arezki *et al*. (2014)	Gold price and rand volatility	12-month rolling Standard deviation	Gold price volatility explains rand volatility
Aye *et al*. (2015)	REER uncertainty and aggregate exports	GARCH-M	Exchange rate volatility negatively affects exports
Farrell (2001)	Capital controls and exchange rate volatility	ARCH, GARCH and EGARCH	Capital controls led to a decline in exchange rate volatility
Bah and Amusa (2003)	Exchange rate volatility and exports to the US	ARCH and GARCH	Real exchange rate volatility exerts a negative influence on exports
Todani and Munyama (2005)	Exchange rate volatility and aggregate exports	MASD, ARCH and GARCH	No relationship is found between exports and exchange rate volatility
Takaendesa *et al*. (2006)	Exchange rate volatility and trade flows	EGARCH	Real exchange rate volatility has a negative impact on exports
Duncan and Lui (2009)	Currency crisis and changes in exchange rate volatility.	GARCH and SC-GARCH	Previously identified currency crisis periods have coincided with changes in exchange rate volatility
Sekantsi (2011)	Exchange rate volatility and exports to the US	GARCH	Exchange rate volatility exerts a negative and significant impact on exports to the US
Wesseh and Niu (2012)	Exchange rate volatility and exports to China	MASD, ARCH and EGARCH	South African exports to China are largely unaffected by exchange rate volatility
Mpofu (2013)	Exchange rate volatility and employment	Moving sample standard deviation	Exchange rate volatility reduces employment growth
Choudry and Hassan (2015)	Exchange rate volatility and UK imports from Brazil, China and South Africa	GARCH	Exchange rate volatility plays an important role in influencing UK trade with Brazil, China and South Africa
Mavee *et al*. (2016)	Drivers of rand/US dollar exchange rate volatility	JSE SAVID, 3-M moving standard deviation and GARCH	Commodity prices, political uncertainty, external economic surprises and global market volatility influence daily USD/ZAR volatility
Mpofu (2016)	Determinants of exchange rate volatility	GARCH and EGARCH	Floating exchange rate policy increase volatility whilst other factors such as trade openness, commodity prices, money supply and FX reserves also influence volatility

A number of studies in the South African literature have looked at the empirical relationship between exchange rate volatility and exports. Amongst these is the one of Todani and Munyama (2005), who apply different measures of volatility (standard deviation, ARCH and GARCH) to study the impact of exchange rate volatility on exports. Their study finds no meaningful, statistically significant relationship between exports and exchange rate volatility, and where such a relationship exists, it is found to be positive such that results from the study were inconclusive. Using an EGARCH model, Takaendesa *et al.* (2006) used data from 1992 to 2004 to indicate that real exchange rate volatility has a negative effect on South African exports to the United States. Also looking at exchange rate volatility and South African exports are Sekantsi (2011), who uses the GARCH (1,1) model to conclude that a rise in real exchange rate volatility leads to lower exports to the United States; Aye *et al.* (2015), who employ the GARCH-in-mean to model the impact of exchange rate volatility on South Africa's aggregate exports. Wesseh and Niu (2012) explore the effects of nominal and real exchange rate volatility on South African exports to China using various measures of volatility (MASD, ARCH and EGARCH) as an indicator of volatility, and Choudhry and Hassan (2015), who use a GARCH (1,1) to model the impact of exchange rate volatility on UK imports from Brazil, South Africa and China. Bah and Amusa (2003) also use ARCH and GARCH volatility measures to model exchange rate volatility effects on South African exports to the US.

Other studies within the South African literature that have focused on the impact of exchange rate volatility of the rand on other economic factors besides trade include Arezki *et al.* (2014). The authors measure exchange rate volatility as the 12-month rolling window of the standard deviation of the REER to indicate that gold price volatility has become a determining factor for the rand's volatility in recent years. Farrell (2001) uses the ARCH, GARCH and EGARCH models to indicate that the imposition of capital controls in the 1985-95 period reduced the volatility of the financial rand as opposed to the period where there was a single exchange rate. Lastly, Mavee *et al.* (2016)apply three tools to approximate exchange rate volatility (the JSE volatility index, rolling standard deviation and the GARCH model) to show that the key drivers of the daily USD/ZAR volatility are commodity prices, political uncertainty, external economic surprises and global market volatility. Mpofu (2013) observes that exchange rate volatility (represented by the moving standard deviation of the real exchange rate) leads to a contraction in employment growth in the country in both the short and long run. Duncan and Liu (2009) use the GARCH and SC-GARCH models to indicate that currency crisis periods in South Africa coincide with structural changes in exchange rate volatility such that sudden changes in volatility could be used to identify the start and end dates of crisis periods. In a study that looks at the determinants of exchange rate volatility, Mpofu (2016) utilises the GARCH and EGARCH models to indicate that shifting policy to a floating exchange rate regime increased rand volatility whilst trade openness reduced exchange rate volatility. What is evident from the above studies is the lack of consistency in the measure of exchange rate volatility used, although the GARCH (1,1) appears quite popular.

The main findings from the literature can therefore be summarised as follows. First, undervalued exchange rates have the potential to contribute positively to exports with overvalued exchange rates having the opposite effect. Secondly, most empirical studies have neglected the issue of asymmetry and nonlinearity when modelling the impact of exchange rate movements on exports. Furthermore, the literature on the nonlinear and asymmetric influence of exchange rate misalignment on exports is scant with no study specific to South Africa identified at the time of conducting this study. Fourthly, most of the literature on exchange rate misalignment and exports has been panel data studies that look at a cross-section of countries with no attention to individual country settings; and lastly, previous studies in South Africa have used different measures of volatility to study the influence of exchange rate volatility on exports and hence produced mixed evidence. The study seeks to enrich the literature by paying specific attention to South Africa and ascertain whether exports react differently to exchange rate undervaluations compared to overvaluations (asymmetry) in the long run at both aggregate and sectoral levels. The essay further tests whether the reaction of exports might differ based on whether such exchange rate misalignment is small or large (exchange rate hysteresis or nonlinearity). Finally, the study pays attention to the reaction of South African exports to exchange rate uncertainty as represented by both misalignment and volatility (as measured through a GJR-GARCH method). Such an analysis has received no attention previously in the South African literature.

5.4 EXPORT BEHAVIOUR AND EXCHANGE RATES IN SOUTH AFRICA: A BRIEF OVERVIEW

South Africa's REER has undergone considerable variations over the past few decades with notable episodes of extreme depreciation and subsequent appreciation (Figure 5.1 below). From a policy perspective, in the period under review, exchange rate policy has been broadly characterised by two exchange rate regimes: a managed float and a freely floating exchange rate policy. Following a currency peg to the British pound prior to 1970 (based on colonial links between Britain and RSA), exchange rate policy shifted to a managed float in the period to the year 2001 before the SARB implemented the current freely floating regime within an inflation targeting monetary policy framework. Within this context, it is also key to note that the political landscape (apartheid regime coupled with global sanctions and isolation pre-1994, and the transition to democracy and subsequent closer links with the global economy) has had a significant impact on historical movements of the country's exchange rate. With the South African economy and financial markets more linked to the global economy, the new policy framework has brought in new challenges in terms of capital flows and contagion from global financial and economic developments, as evidenced by the most recent global financial crisis which caused the rand to depreciate significantly.

According to Ricci (2005), exchange rate movements (and the volatility thereof) have an influence on trade flows under incomplete markets or in circumstances where hedging costs are substantial; with such volatility also negatively influencing investment decisions associated with international trade. The evolution of the rand's REER and its movements compared to total exports is indicated in Figure 5.1. As a percentage of GDP, exports declined from around 30% in the mid-80s to levels near 20% at the end of 1995. Supported by trade liberalisation and export-oriented trade agreements such as the General Export Incentive Scheme and the African Growth and Opportunity Act (Sekantsi, 2011) export performance improved from 1996 onwards to peak at 36.8% of GDP in 2007, before declining to 31% at the end of 2014. Despite this improved performance, it has been well noted that South Africa's export performance remains poor relative to that of its emerging market peers (Anand *et al.*, 2016), hence the need for policymakers to get a better understanding of all economic factors (including exchange rates) driving the country's exports.

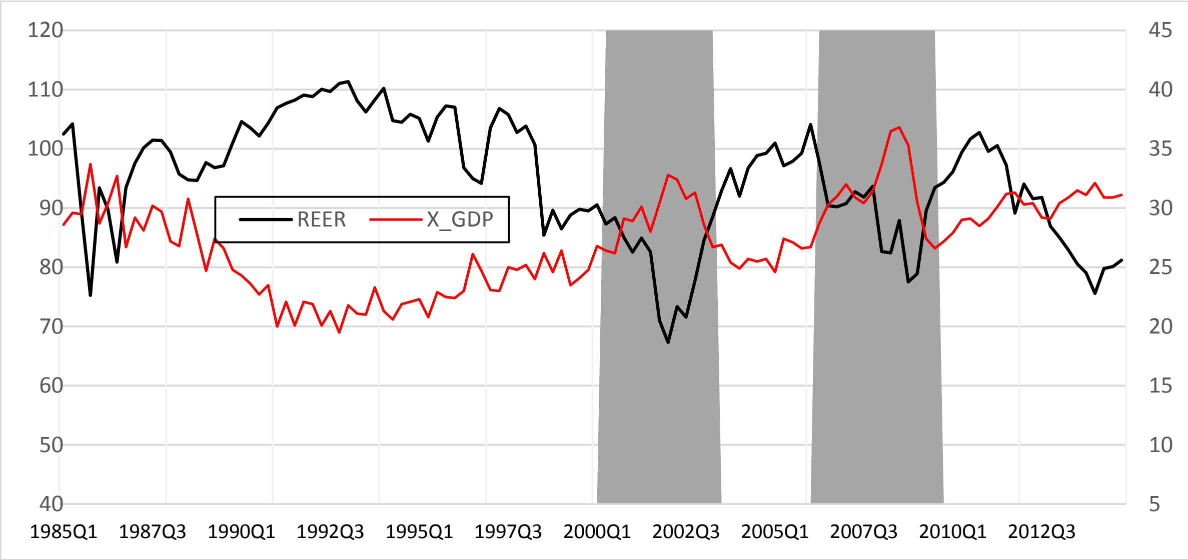

Figure 5.1: REER versus exports as a percentage of GDP

Note: Data source is the SARB

As indicated in Figure 5.1 above, total exports in South Africa (especially in the period after year 2000) appear to be positively correlated with a weaker exchange rate since episodes of exchange rate depreciation (shaded areas) have been associated with higher exports[36]. The opposite holds true for periods where the exchange rate was appreciating as total exports are seen declining (e.g. late 2002–2005). This relationship is also confirmed by Edwards and Garlick (2008) and as such justifies the need for an empirical analysis of the relationship between exports and the exchange rate to ascertain whether indeed an undervalued currency boosts exports. In addition to aggregate exports, the analysis in this study is extended to assess the impact of exchange rate misalignment on sectoral exports: manufacturing, mining and agriculture. These sectors are chosen due to their important contribution to total exports, economic growth and their potential to absorb the unskilled and semi-skilled labour that makes up a major majority of the unemployed South Africans[37]. Bhorat, Naidoo, Oosthuizen and Pillay (2016) note that the slow growth observed in the labour intensive sectors of the economy is one major reason behind the failure to absorb increasing levels of labour force participation in the country. Also related to this is the National Development Plan (Vision 2030)

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[36] A negative correlation coefficient of -0.75 was found between the REER and exports in the sample period (decline in REER represents a depreciation), thus confirming a strong association between exchange rate depreciation and the volume of exports.

[37] As at the end of 2014, manufacturing contributed about 60% to total goods exports, with mining (and quarrying) and agriculture contributing 35% and 3% respectively (data from Quantec).

which calls for increasing exports in mid-skill manufacturing, mining and agriculture as a way to boost job creation and economic growth.

5.5 METHODOLOGY

5.5.1 Exchange rate misalignment

The first main step in the analysis involves measuring the degree of exchange rate misalignment of the rand and this mainly entails modelling the equilibrium relationship between the REER and its economic fundamentals, and then computing the misalignment as the deviation of the actual REER from its equilibrium level. It is essential to mention that with the equilibrium exchange rate unobservable, there are different approaches to its estimation such that estimation methods are far from consensual and any results applied are linked to the methodology chosen. Broadly, the three approaches that have been widely used in the literature are the PPP, FEER and BEER methods (see studies such as Driver and Westaway (2004) and MacDonald (2000) for a full comprehension of the different methods).

In similar fashion as the previous chapter, the exchange rate misalignment series used in the study is adopted from Chapter 2 (Essay 1) where the BEER method introduced by Clark and McDonald (1998) is applied. The misalignment series is then measured as the deviation of the exchange rate from the equilibrium level estimated as a long-term relationship between the REER and economic fundamentals. The following equation was estimated to compute the equilibrium REER:

$$Lreer_t = \alpha + \beta_1 Ltot + \beta_2 Lopen + \beta_3 K\_flows + \beta_5 Lgov + \epsilon_t \quad \text{...(5.7)}$$

with *Lreer* the log of the REER, *Ltot* representing terms of trade (log form), external openness as *Lopen (*log form), net capital inflows as *K_flows* and government expenditure as *Lgov* (log form). The Johansen procedure was used in the BEER framework to confirm the presence of a long-run relationship between the REER and the variables above. Subsequent to confirming cointegration of the variables and the endogeneity of the exchange rate in the model, the Dynamic Ordinary Least Squares (DOLS) method was then applied to estimate the long-run cointegrating equation. Misalignment is then expressed as the difference between the observed REER and its predicted equilibrium value (as per Equation 5.7). Following estimation of the misalignment series, the variable is added as one of the explanatory variables in an export demand function. In order to capture elements of asymmetry and nonlinearity, the study follows scholars such as Verheyen (2013), Bussière (2013), Sekkat (2016) and Fadoseva and Werner (2016) who apply nonlinear techniques to study the influence of exchange rate movements to either export demand or prices.

5.5.2 Export demand model

The model adopted in this essay draws from the theory of international trade and the conventional determining factors that drive trade volumes. The empirical approach applied is the same as in Todani and Munyama (2005), Takaendesa *et al.* (2006) and Sekantsi (2011), where a standard export demand equation is estimated as a function of variables that include foreign income, relative prices and exchange rate uncertainty. Given the focus of the study and in a similar vein to previous empirical studies (e.g. Diallo, 2011; Sekkat & Varoudakis, 2000), this study extends the export demand model by incorporating the term 'misalignment', which is the deviation of the REER from its equilibrium level. The export demand model is therefore in the study expressed as a function of foreign income, relative prices, terms of trade and exchange rate misalignment as follows:

$$LEX_t = \beta_0 + \beta_1 LY_t + \beta_2 PX_t + \beta_3 TOT_t + \beta_4 MIS_t + u_t \quad ...(5.8)$$

where LEX_t represents the logarithm of real exports (nominal exports deflated by consumer prices (CPI)), LY_t is the of log real foreign income (proxied by U.S. industrial production) and is used as an indicator of demand for South African exports. LPX_t indicates relative prices and acts as an indicator of external competitiveness and is measured as a log of the REER, MIS_t is the exchange rate misalignment series, u is the disturbance term and t refers to time period. Theory postulates a positive relationship between foreign income and South African exports such that β_1 is expected to be positive with an increase in foreign income raising the demand for South African goods for export[38]. Regarding prices, the higher the export price, the lower would be the demand for exports such that β_2 is theoretically expected to be negative. The same applies for terms of trade since an increase in South Africa's terms of trade (*ceteris paribus*) implies that export prices are rising faster than import prices which should be negative for exports. Since exchange rate misalignment (as represented by one series) signals an exchange rate in disequilibria, β_3 should be negative as any form of misalignment is seen as bad for exports according to the Washington Consensus. MIS_t therefore represents the key variable of interest in the model.

5.5.3 The asymmetric ARDL model

To estimate the effects of exchange rate misalignment on exports, the autoregressive distributed lag (ARDL) bounds testing methodology of Pesaran *et al.* (2001) is used. The ARDL model is an error-correction specification that allows for investigating a short-run and long-run relationship amongst the variables of interest through cointegration techniques. This approach uses lags of the dependent variable and the lagged and contemporaneous values of the independent variables such that the short-run effects can be directly estimated and the long-run equilibrium relationship indirectly inferred (Bouchoucha, 2015). The baseline ARDL export demand regression model for this study (without asymmetry in the short-run and long-run dynamics) is specified as follows:

[38] The main assumption here is that the exported goods are not inferior goods since the demand for such goods declines with rises in income. For inferior goods, β_1 would be negative.

$$\Delta LEX_t = \alpha_0 + \alpha_1 LEX_{t-1} + \alpha_2 LY_{t-1} + \alpha_3 LPX_{t-1} + \alpha_4 LTOT_{t-1} + \alpha_5 MIS_{t-1} + \sum_{i=1}^{n} \beta_1 \Delta LEX_{t-i} + \sum_{i=1}^{n} \beta_2 \Delta LY_{t-i} + \sum_{i=1}^{n} \beta_3 \Delta LPX_{t-i} + \sum_{i=1}^{n} \beta_4 \Delta LTOT_{t-i} + \sum_{i=1}^{n} \beta_5 \Delta MIS_{t-i} + u_t \qquad \ldots(5.9)$$

Pal and Mitra (2015) state that the relative attractiveness of an ARDL model when testing for cointegration (as opposed to other methods as suggested by Engle and Granger (1987) and Johansen and Juselius (1990)) is that it can be applied regardless of whether the variables in the model are stationary, I(1) or fractionally integrated (although not I(2)). Secondly, the model allows for simultaneous estimation of both short-run and long-run parameters and is also suitable for small samples. Lastly, the ARDL model is valid even if the explanatory variables are endogenous. In order to test for cointegration in Equation 5.9, the null hypothesis of H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$ is tested (against the alternative H_1: $\alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq 0$) using the bounds test (F test) as proposed by Pesaran *et al.* (2001). The bounds test uses two critical values (the upper and lower bounds) such that if the computed value of the F test statistic exceeds the upper bounds, one can conclude that a long-run equilibrium relationship exists. Should the critical statistic fall below the lower bound, no evidence of cointegration is confirmed; while a critical value that lies between the lower and upper bounds gives inconclusive results (Athanasenas & Katrakilidis, 2014).

As well noted in recent literature (e.g. Katrakilidis & Trachanas (2012); Verheyen (2013); Bahmani-Oskooee & Mohammadian (2016)), the major shortcoming of the linear ARDL model specified above (Equation 5.9) is its failure to capture the possible asymmetry and nonlinearity in the reaction of exports to exchange rate overvaluations and undervaluations as represented by the variable of interest *MISt*. This is a pertinent issue since exports should react differently to an undervalued exchange rate as opposed to an overvalued currency. Other factors such as market power, price and volume rigidities, switching costs and capacity constraints might affect the reaction of exports to exchange rate movements such that it is not only the sign of the exchange rate misalignment that is important for exports but also the magnitude or size of such exchange rate movements.

In order to cater for potential asymmetries in the export demand equation, I apply the approach of Shin *et al*. (2011) which is subsequently used in other studies such as Bahmani-Oskooee and Mohammadian (2016), Verheyen (2013) and Atil *et al.* (2014) and estimate an asymmetric ARDL model that allows for short-run and long-run asymmetries. To this end and in order to test the hypothesis of asymmetry in the export demand model, we follow the approach of Sekkat (2016) in decomposing the misalignment series (MIS_t) into its positive (rand overvaluation) and negative (rand undervaluation) partial series. This achieved by creating a dummy variable that takes the value of 1 for quarters where the currency was overvalued and zero for undervaluation periods. Interacting the dummy with the misalignment series generates the overvaluation series with the undervaluation series generated by the interaction of the alternative (1-dummy). More specifically, such a method allows us to separate the misalignment series in terms of direction as follows:

$$Over\_v_t \begin{cases} = Mis_t \text{ if } Mis_t > 0 \\ 0 \text{ otherwise} \end{cases}$$

$$Under\_v_t \begin{cases} = Mis_t \text{ if } Mis_t < 0 \\ 0 \text{ otherwise} \end{cases} \quad \ldots(5.10)$$

Accordingly, the asymmetric ARDL becomes an extension of the normal ARDL bounds testing technique of Shin *et al*. (2001) where MIS_t in *(9)* is replaced by Over_v_t and Under_v_t , thus allowing me to generate a new cointegration model as follows (see e.g Verheyen (2013); Pal & Mitra, 2015; Bahmani-Oskoee *et al.*, 2016[39]):

$$\Delta LEX_t = \alpha_0 + \alpha_1 LEX_{t-1} + \alpha_2 LY_{t-1} + \alpha_3 LPX_{t-1} + \alpha_4 LTOT_{t-1} + \alpha_5 Over\_v_t + \alpha_6 Under\_v_t + \sum_{i=1}^{n} \beta_1 \Delta LEX_{t-i} + \sum_{i=1}^{n} \beta_2 \Delta LY_{t-i} + \sum_{i=1}^{n} \beta_3 \Delta LPX_{t-i} + \sum_{i=1}^{n} \beta_4 \Delta LTOT_{t-i} + \sum_{i=1}^{n} \beta_5 \Delta Over\_v_{t-i} + \sum_{i=1}^{n} \beta_6 \Delta Under\_v_{t-i} + u_t \quad \ldots(5.11)$$

The asymmetric ARDL method stated above has been applied in several studies, e.g. Delatte and López-Villavicencio (2012) who assess the nonlinear effects of the exchange rate on prices. Mitra (2013) uses the model to study the asymmetric influence of rainfall on grain production in India. Bognai and Ospina (2015) apply the approach to investigate the presence of asymmetry and hysteresis in the relationship between the exchange rate and gasoline prices in Italy. The additional variables in Equation 5.11 introduce nonlinearity into the export demand model thus allowing me to test whether exchange rate misalignment has asymmetric effects on exports. Wald tests are applied to formally test for long-run asymmetry in model 11[40]. I therefore apply this method to test for asymmetry and hysteresis in the influence of misaligned exchange rates on exports in South Africa.

5.5.4 Multiple Threshold NARDL Model (exchange rate hysteresis)

Since the influence of exchange rate movements on exports could be determined by the size of the misalignment, I further extend the analysis by applying thresholds to distinguish between the effects of small and large exchange rate misalignments. This is based on the possibility of hysteric effects such that exports could only react if there are considerable movements in the exchange rate or if the level of misalignment is beyond certain "bands of inaction". It is well noted for example, by Bussière (2013) that the size of exchange rate movements in the ERPT to exports cannot be ignored. Different

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[39] These studies have applied the methodology to study the effects of appreciation versus depreciation and hence use partial sums of appreciation and depreciation, whilst this study considers overvaluation versus undervaluation which is deviation from an equilibrium.
[40] Long-run asymmetry is achieved by testing the coefficient restriction *α5 = α6* and rejection of this restriction means asymmetry is present.

approaches towards measuring hysteresis can be found in the literature; e.g. Verheyen (2013) uses 30% and 70% quantiles of exchange rate movements to distinguish small from large movements, Pal and Mitra (2015) apply multiple quartiles (20^{th}, 40^{th}, 60^{th} and 80^{th}), and Mitra (2013) applies one standard deviation above and below the average to separate small from large changes. Bagnai and Ospina (2015) note that currently there are neither theoretical nor empirical directions as to how thresholds for measuring hysteresis should be determined. In order to account for the potential presence of hysteresis and the possible existence of an inaction band where exports do not react to exchange rate misalignment episodes (both over and undervaluation), I follow the approach taken by Pollard and Coughlin (2004) and Bussière (2013), and apply a two-threshold decomposition of the exchange rate misalignment series to separate small from large misalignment episodes (3%, 5%, 7% and 10% are used as the thresholds for testing hysteresis). For example, a 5% threshold that separates small from large overvaluation sizes of exchange rate misalignment can be specified as follows:

$$L\_over\_v_t = \begin{cases} \text{Mist if } Mis_t > 5\% \\ 0 \text{ otherwise} \end{cases} \qquad S\_over\_v_t = \begin{cases} \text{Mist if } 0 < Mis_t \leq 5\% \\ 0 \text{ otherwise} \end{cases} \qquad \ldots(5.12)$$

where *L_over_vt* and *S_over_vt* represent episodes of large and small overvaluations respectively. In a similar manner to Karoro *et al.* (2009), models are specified that include either one of the series (e.g. small overvaluation below 5%) or both overvaluation and undervaluation (e.g. small overvaluation below 5% together with small undervaluation above -5%). These are specified in the ARDL export model (as in Equation 5.11) to test for the impact of both the direction and size of the exchange rate misalignment. Three sets of models were run: equations that include the undervalued series alone, overvaluation series alone and equations that include both series at similar thresholds. Should the results from the asymmetric ARDL model confirm that the coefficients for small undervaluations (at different thresholds) are statistically significant and different from the coefficients of large undervaluations, this would indicate that exports react differently to small versus large exchange rate undervaluations. A similar conclusion based on overvaluation thresholds would also make it possible to confirm the presence of hysteresis in the reaction of exports to exchange rate misalignment occurrences.

5.5.5 Data and variables

Real exports (LEXt)

The dependent variable in the export model (exports in log form) is expressed in real terms where I deflate South Africa's gross nominal exports with the consumer price index (see Todani & Munyama, 2005, Fedoseeva, 2016). Datasets for merchandise exports and consumer prices (rebased to 2010) was obtained from the SARB. The study uses quarterly data from 1985:Q1 to 2014:Q4[41].

Foreign income (LY_t)

The variable LY_t is used to measure foreign income and indicates the potential demand for South African exports. This follows previous studies (e.g. Sekantsi, 2011) and uses US Industrial Production figures (in log form with 2010 as base year) as a proxy for foreign demand. Expressed in index form, the US Industrial Production data was obtained from the Federal Reserve Bank of St Louis Database. An increase in foreign income is expected to be associated with higher South African exports.

Relative prices (LREERt)

The REER of the South African rand is used as a measure of relative prices (REER is expressed in domestic currency terms and also in log form). Calculated as the trade weighted NEER of the rand (against a basket of currencies that form the country's major trading partners) adjusted for inflation differentials, the REER is regarded as an indicator of the country's competitiveness in international markets. An appreciation in the REER is expected to have a negative impact on exports with a depreciation supporting exports. Data for this variable was obtained from the SARB.

Terms of trade (LTOTt)

Terms of trade (expressed in log form) is a control variable used in the study and this is calculated as the relative price of the country's exports to the price of imports. Also obtained from the SARB, the data used is terms of trade excluding gold and represents the ratio between the prices of the country's exports and the prices of its imports (export price index divided by the import price index). An increase or improvement in the terms of trade should theoretically lead to a rise in exports since it implies export prices are rising faster than import prices, although the relationship can be rather indistinct.

Sectorial exports

There is a general problem regarding the availability of sectorial exports data in South Africa. Hence, I use data on gross value added from three sectors (manufacturing; agriculture (includes forestry and fishing); and mining and quarrying) stated at constant 2010 prices as proxies for sectoral exports[42]. This data is also obtainable from the SARB.

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[41] Tables 6.3 and 6.4 in the appendix provide summary descriptive statistics and Pairwise correlations.

[42] Fowkes *et al*. (2016) also note the problem of data availability and use manufacturing gross value added (GVA) as a proxy for manufactured exports since South Africa does not have such data. Quantec has data available but unfortunately this did not cover the full sample period of the study.

Exchange rate misalignment

In a similar vein to essay 3 (Chapter 4), the exchange rate misalignment series used in the study is adopted from the first essay of the thesis (Chapter 2). A BEER method is used to estimate misalignment as the deviation of the observed exchange rate from its estimated equilibrium level specified as a long-run relationship between the REER and the terms of trade, external openness, government expenditure and net capital flows.

Exchange rate volatility

Volatility is used in addition to misalignment as another indicator of exchange rate uncertainty or risk which has the potential to influence South African exports. The GJR-GARCH (1,1) model is adopted in the study as the appropriate measure for the rand's volatility. As an extension of the GARCH (1,1) model, the GJR-GARCH model improves on volatility estimates by taking into account leverage effects. Over the sample period data, this model was chosen as it performed better compared to the GARCH (1,1) and EGARCH (1,1) models based on statistically significant coefficients (GARCH and leverage effect), a stationary conditional variance process ($\alpha 1 + \beta 1 < 1$), satisfaction of the non-negativity constraints and the fact that the model eliminates ARCH effects.

5.5 EMPIRICAL RESULTS

The ARDL cointegration method necessitates that I determine the time series properties of the variables entering the model since the presence of I(2) variables would render the computed F-test statistics invalid, hence lead to misleading results (Athanasenas & Katrakilidis, 2014). I examined the order of integration among the variables using the ADF and the Break Point Unit Root Test was used as an alternative, with the results presented in Table 5.4 below. The findings suggest that the variables (real aggregate exports, foreign income, relative prices, terms of trade, and manufactured exports) are nonstationary in levels but become stationary at first differences, with all the misalignment series (agricultural exports, mining exports and exchange rate volatility data) stationary at level.

The Breakpoint Unit Root test confirms that the underlying variables hold similar stationarity properties even under the possible presence of structural breaks in the series. The combination of I(1) and (I(0) variables hence renders the ARDL model appropriate since none of the variables are I(2). I thus proceeded with testing for cointegration in the ARDL framework using the specifications derived from both the symmetric and asymmetric export demand models. Such ARDL models are applied to both aggregate exports and sectoral exports (agriculture, mining and manufacturing). Finally, thresholds were applied to the misalignment data in order to test whether small versus large misalignment episodes have different effects (as per Equation 5.12), and this is done for both total and sectoral exports.

Table 5.4: Unit root test results

Augmented Dickey-Fuller					
	Level		**First Difference**		**Conclusion**
Variable	***Intercept***	***Intercept & Trend***	***Intercept***	***Intercept & Trend***	
LEX_t	-0.55	-3.18*	-15.00***	-14.99***	I(1)
LY_t	-1.51	-1.73	-5.12***	-5.20***	I(1)
$LREER_t$	2.69*	-3.08	11.26***	-11.22***	I(1)
MIS*t*	-4.52***	-4.50**	-13.04***	-12.99***	I(0)
$LTOT_t$	-1.83	-2.84	-9.42***	-9.41***	I(1)
Under_Vt	-4.02***	-5.12*	-13.87***	-13.81***	I(0)
$Over\_V_t$	-3.52**	-4.01***	-11.01***	-10.97***	I(0)
Lagric	-0.13	-6.12***	-7.28***	-7.29***	I(0)
Lmanuf	-0.28	-2.42	-7.68***	-7.67***	I(1)
Lmng	-4.05***	-4.28***	-14.14***	-14.11***	I(0)
Vol_t	-5.932***	-5.952***	-15.061***	-14.996***	I(0)
Breakpoint Unit Root Test					
	Level		**First Difference**		**Conclusion**
Variable	***Intercept***	***Intercept & trend***	***Intercept***	***Intercept & Trend***	
LEX_t	-2.39	-4.29	-15.72***	-15.95***	I(1)
LY_t	-2.94	-4.79*	-6.31***	-6.57***	I(1)
LREERt	-3.66	-3.77	-11.73***	-11.76***	I(1)
MIS_t	-4.95***	-5.06**	-13.76***	-13.67***	I(0)
$LTOT_t$	-4.70*	-4.71*	-16.87***	-16.91***	I(1)
Under_V	-5.94***	-5.79***	-14.97***	-15.00***	I(0)
Over_V	-4.70**	-5.02**	-11.83***	-11.74***	I(0)
Lagric	-5.36***	-9.14***	-9.05***	-8.90***	I(0)
Lmanuf	-2.38	-3.85	-8.78***	-8.79***	I(1)
Lmng	-5.21***	-5.00***	-14.78***	-14.72***	I(0)
Vol_t	-8.822***	-9.003***	-20.692***	-20.677***	I(0)

Note: *, **, *** denote significance at 10%, 5% and 1% respectively

Null hypothesis is that there is unit root in all cases.

Lagric, Lmanuf, Lmng and Vol_t represent agriculture, manufacturing, mining and volatility respectively

5.6.1 Exchange rate misalignment and aggregate exports

Table 5.5: Bounds test for cointegration in the linear and asymmetric specifications (total exports)

	F Statistic	95% Lower Bound	95% Upper Bound	Conclusion
Dependent variable is LEX				
Linear ARDL (2,0,5,6,1) (including only MIS_t)	5.016***	2.56	3.49	Cointegration
Asymmetric ARDL (6,1,5,6,7,2) (incl. Under_v and Over_v)	5.800***	2.39	3.38	Cointegration

*, **, *** indicates statistical significance at 10%, 5% and 1% respectively

The ARDL bounds test results (Table 5.5) reveal statistically significant evidence in favour of a long-run cointegrating relationship between aggregate exports and the variables chosen for both models since the F-Statistics for the two specifications (linear ARDL and asymmetric ARDL) exceed the upper bound critical values at a 1% level of significance.

Table 5.6 below presents the estimated long-run linear ARDL and asymmetric ARDL model coefficients as estimated by Equations 5.9 and 5.11. The results from the linear ARDL model show that all the long-run coefficients (including exchange rate misalignment) carry the expected signs although the relative prices (real exchange rate) and misalignment variables are not statistically significant. The results indicate that a 1% increase in foreign income (as represented by US Industrial Production) is associated with a 2.35% rise in South African exports in the long run. A 1% rise in South Africa's terms of trade increases real exports by approximately 2.84%. Whilst a favourable movement in the terms of trade should theoretically lead to a decline in exports, the final impact largely depends on the relative price elasticity of demand for exports and imports. The positive relationship identified in the study could be attributed to either the possibility that South Africa's exports are price inelastic as increases in prices have no major impact on exports, or an improvement in terms of trade that has been driven by declining import prices. Although the coefficient for misalignment is negative (-0.004) it is not statistically significant. The implication is that exchange rate misalignment in whatever form might represent uncertainty such that it hinders South African exports in the long run. Such a conclusion is confirmed by the short-run coefficient which is negative and statistically significant at a 5% confidence level (-0.027). As reported in Table 5.6, the coefficient of the error correction term in the ARDL model (-0.287) has the correct sign, is statistically significant and high. This confirms the long-run equilibrium relationship amongst the variables whilst also suggesting a fair adjustment process (about 29% of the disequilibrium in the previous quarter's shock would adjust back to equilibrium in the current quarter).

Regarding the asymmetric model, the coefficients over_v and under_v are different in sign and size, thus allowing me to confirm asymmetry in the reaction of aggregate exports to exchange rate under- versus overvaluation. The overvaluation coefficient is negative and statistically significant at 5% (-

0.035) whilst the undervaluation value is positive although not statistically significant (0.028). To corroborate the findings, the Wald test was used to formally test for long-run asymmetry, and showed that the null hypothesis of long-run symmetry between undervaluation and overvaluations is rejected at the 5% level of confidence. Table 5.6 also shows that the estimated error correction term is negative (high) and statistically significant, implying a quick adjustment every quarter (about 35%) in the cointegrating equation.

Table 5.6: Results of ARDL and NARDL models (total exports)[43]

ARDL Model				NARDL Model		
Dependent Variable: LEX						
Long-run coefficient estimates						
Variable	**Coefficient**	**t-Statistic**		**Variable**	**Coefficient**	**t-Statistic**
LY	2.356	10.066***		LY	2.894	9.097***
LREER	-0.593	-1.147		LREER	-0.472	-0.894
LTOT	2.846	10.658***		LTOT	2.706	7.902***
MIS___	-0.004	-0.499		UNDER_V	0.028	1.407
C	-12.491	-3.616***		OVER_V	-0.035	-2.565**
				C	-14.695	-4.062
CointEq(-1)	-0.287	-5.630***		*CointEq(-1)*	*-0.346*	*-6.615****
B-G LM Test	0.560 (0.572)			*B-G LM Test*	*0.649 (0.690)*	
BPG Test	1.474 (0.117)			*BPG Test*	*1.495 (0.077)*	
				Wald Test	*-2.482 (0.015)*	
CUSUM	S			*CUSUM*	S	
CUSUMQ	S			*CUSUMQ*	S	

*, **, *** indicates statistical significance at 10%, 5% and 1% respectively
The Breusch-Godfrey LM Test (B-G LM) and Breusch-Pagan-Godfrey Heteroscedasticity (BPG) tests were used for serial correlation and heteroscedasticity respectively.
For CUSUM and CUSUMQ: S is stable and U is unstable

The conclusion therefore is that exports suffer more from an overvalued exchange rate, with the benefits realised from an undervalued exchange rate minimal. The short-run results do not indicate any meaningful effects of either exchange rate undervaluation or overvaluation on exports. Application of the diagnostic tests suggests that the linear model is free from serial correlation and heteroscedasticity with the parameters stable since the CUSUM and CUSUMQ statistics (Figure 5.2)

[43] Only the long-run coefficients are reported: results from the short-run model are available upon request. Two different models were also run: these included each of the misalignment variables (over_v and under_v) and the results were in line with those reported in Table 5.6 although the coefficients were not statistically significant.

are well within the critical bounds. The same applies for the nonlinear specification although the model might be prone to a minor heteroscedasticity problem. Granger causality tests that included the error correction term also led to a conclusion that a one-way long-run causal relationship from exchange rate misalignment (overvaluation and undervaluation) to exports can be identified in the data (see Table 6.5 in Appendix 2).

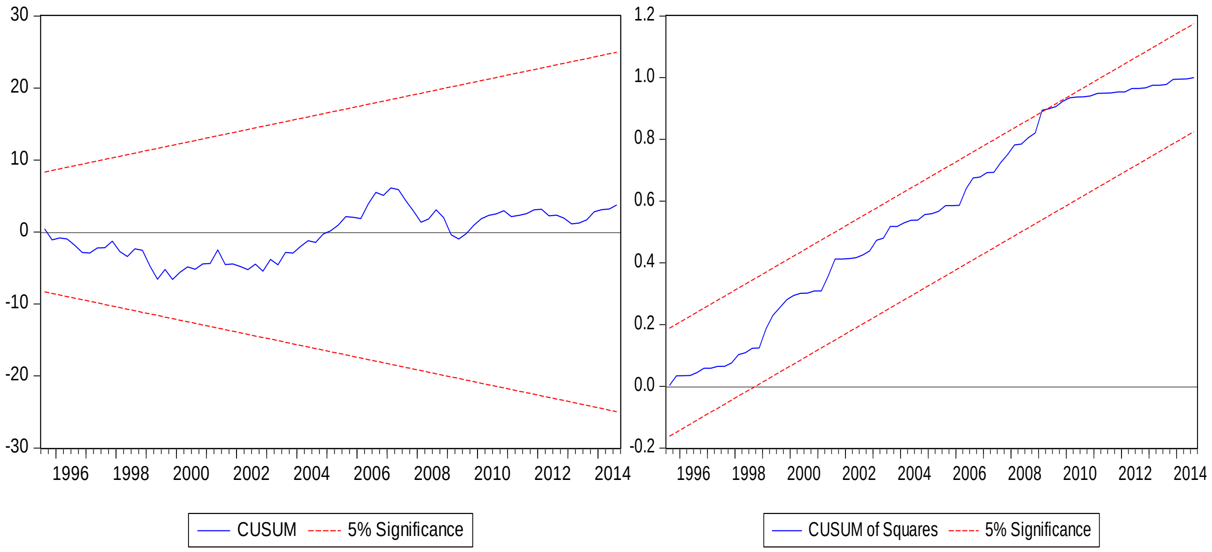

Figure 5.2: CUSUM AND CUSUMQ (Asymmetric ARDL Model)

Although an undervalued exchange rate could contribute positively to export performance, exchange rate risk, as represented by volatility of the exchange rate, has the potential to offset or even dominate the positive effects (Fang *et al.,* 2016). This is on the premise that exchange rate volatility should theoretically have a negative influence on exports. The analysis is further extended along the lines of Ahmad *et al.* (2010), where the influence of exchange rate misalignment and volatility on South African exports is tested, with the results reported in Table 5.7 below. Given that both exchange rate misalignment and volatility represent uncertainties that can influence the behaviour of exporters, I seek to ascertain either whether a combination of these factors can influence exports, or whether one of the two sources has a stronger influence on trade flows as suggested by Fang *et al.* (2006). For comparison purposes, two export demand models are estimated: one with only volatility as an interest variable and another that includes volatility in an asymmetric framework with both over- and undervaluation.

Under the basic linear model, where only volatility is added as a further explanatory variable to the export demand model, the bounds test statistic (1.157) fails to confirm cointegration amongst the variables and the estimated volatility coefficient is negative but not statistically significant (Model 2: Table 5.7). When the volatility variable is added to the asymmetric model (inclusive of over- and undervaluation), the volatility coefficient is negative and statistically significant, implying that exchange rate volatility, when considered together with an overvalued exchange rate, exerts a negative influence on South African exports. The coefficient for overvaluation is negative and statistically significant, with undervaluation positive but not significant. Furthermore, the Wald test statistic for long-run symmetry between undervaluation and overvaluation is rejected at the 1% level of confidence. Of note is that this model appears superior to the earlier asymmetric model that excludes volatility since the latter model is also free of heteroscedasticity. This finding is consistent with conclusions made by prior studies on South Africa (e.g. Sekantsi, 2011; Bah & Amusa, 2003) that exchange rate volatility indeed exerts a negative influence on South African exports. In a nutshell, exchange rate overvaluation plus volatility has a negative impact on South African aggregate exports, with exchange rate undervaluation exerting no statistically meaningful positive influence on aggregate exports. These results are similar to the observations in Chapter 4, where asymmetry is confirmed in the response of economic performance to exchange rate under- versus overvaluation. The main difference here is that volatility, together with misalignment, has an influence on exports, unlike in the previous chapter where volatility had no impact on economic performance when either considered alone or together with exchange rate misalignment.

Table 5.7: Exchange rate misalignment, volatility and exports

	Model 1 Under_v, Over_v & Volatility			Model 2 Volatility	
Variable	**coefficient**	**t-statistic**		**coefficient**	**t-statistic**
Long-run coefficient estimates					
LY	2.909	13.335***		2.542	2.811***
LREER	-0.380	-1.001		-1.098	-1.075
LTOT	2.763	10.842***		1.442	0.765
Over_v	-0.023	-2.863***			
Under_v	0.010	0.773			
VOL_T	-70.406	-2.664***		-19.958	**-0.242**
constant	-15.423	-6.130***		-4.702	-0.583
ECM_{t-1}	-0.432	-9.491***		-0.092	-2.703**
Bounds Test	10.311***			1.157	
Wald Test	3.647 (0.000)				
B-G LM Test	0.858 (0.529)			0.936 (0.395)	
BPG Test	1.084 (0.376)			1.194 (0.281)	
CUSUM	S			S	
CUSUMQ	S			U	

*, **, *** indicates statistical significance at 10%, 5% and 1% respectively

The Breusch-Godfrey LM Test (B-G LM) and Breusch-Pagan-Godfrey Heteroscedasticity (BPG) tests are used for serial correlation and heteroscedasticity respectively.
For CUSUM and CUSUMQ: S is stable and U is unstable

5.6.2 Exchange rate misalignment and sectorial exports[44]

Table 5.8: ARDL bounds test for cointegration (sectoral exports)

Linear models						
	Agriculture		***Mining***		**Manufacturing**	
F-Statistic	1.92		*4.56****		2.36	
Asymptotic critical values						
	I(0)	**I(1)**	***I(0)***	***I(1)***	**I(0)**	**I(1)**
10%	2.22	3.09	*2.20*	*3.09*	2.20	3.09
5%	2.56	3.49	*2.56*	*3.49*	2.62	3.49
1%	3.29	4.37	*3.29*	*4.37*	3.41	4.37
Conclusion	No Cointegration		***Cointegration***		No Cointegration	

Tables 5.8 and 5.9 present the results for the bounds test for cointegration for the sectoral exports; i.e. agriculture, mining and manufacturing. The results are presented based on two model specifications: the first one used as a benchmark with a single series (linear model) for the misalignment variable (Table 5.8) and the second set (Table 5.9) being export demand models that cater for potential asymmetry by separating overvaluation from undervaluation episodes. Results from linear models reveal statistically significant evidence in favour of a long-run cointegrating relationship between exports at sector level only for mining[45] exports, with agriculture and manufacturing indicating no long-run relationship.

Table 5.9: NARDL bounds test for cointegration (sectoral exports)

Asymmetric models						
	Agriculture		**Mining**		**Manufacturing**	
F-Statistic	1.65		2.43		3.80**	
Asymptotic critical values						
	I(0)	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
10%	2.08	3.00	2.08	3.00	**2.08**	**3.00**
5%	2.39	3.38	2.39	3.38	**2.39**	**3.38**
1%	3.06	4.15	3.06	4.15	**3.06**	**4.15**
Conclusion	No cointegration		No cointegration		**Cointegration**	

[44] The model specifications for symmetrical and asymmetric models (results in Tables 5.6 and 5.7) is similar to the total exports models (Equations 5.9 and 5.11 with the only difference being the dependent variable in the models above is sectoral exports (Agriculture, Mining and Manufacturing): e.g. Manufacturing is $LMANUF\_X_t = \beta_0 + \beta_1 LY_t + \beta_2 PX_t + \beta_3 TOT_t + \beta_4 MIS_t + u_t$ & $LMANUF\_X_t = \beta_0 + \beta_1 LY_t + \beta_2 PX_t + \beta_3 TOT_t + \beta_4 UNDER\_V_t + \beta_5 OVER\_V_t + u_t$ for both linear (ARDL) and nonlinear models (NARDL) respectively.

[45] Although cointegration is confirmed for this model, most of the long-run model coefficients are not significant and the model is dropped from further analysis.

Regarding the nonlinear specifications which are the main area of interest for the study, the F-statistic for the equation for agriculture does not exceed the upper bound critical values, thus allowing me to accept the null hypothesis of no long-run relationship amongst the variables. For mining exports, the F-statistic lies between the 10% bound critical values indicating that the result is inconclusive, hence the two models (agriculture and mining) are dropped from further analysis. The results are however different for the manufacturing sector as the F-Statistic is statistically significant at a 5% level of confidence, allowing me to conclude in favour of cointegration. Following the bounds test, I went on to estimate three equations that represent export demand for manufactured goods to establish if exchange rate overvaluation, undervaluation and volatility has an influence on manufacturing exports. Table 5.10 shows the results (long-run coefficients) for the asymmetric models (one model without volatility and the other inclusive of volatility) and another model where volatility only is added to the manufactured exports demand specification.

Table 5.10: Exchange rate misalignment and manufactured exports

Dependent variable: lmanuf						
	Model 1 Under_v, Over_v		**Model 2 Under_v, Over_v & Volatility**		**Model 3 Volatility**	
Variable	coefficient	t-statistic	coefficient	t-statistic	coefficient	t-statistic
Long-run coefficient estimates						
LY	0.968	3.375***	1.382	4.812***	0.758	3.018***
LREER	-0.801	-1.515	0.375	0.822	-0.530	-1.283
LTOT	0.831	3.365***	0.780	4.910***	0.929	2.406**
Over_v	-0.009	-1.143	-0.019	-2.417**		
Under_v	0.029	1.747*	-0.006	-0.649		
VOL_T (1)			-51.090	-2.491**	-15.881	-0.906
constant	8.276	2.718***	1.248	0.432	7.466	3.367***
ECM_{t-1}	-0.085	-5.332***	-0.127	-6.832***	-0.049	-2.984
Bounds Test	3.808**		5.371***		1.419	
Walt Test	1.023 (0.308)		1.876 (0.077)			
B-G LM Test	0.337 (0.562)		0.230 (0.632)		0.515 (0.474)	
BPG Test	1.371 (0.166)		0.998 (0.480)		1.526 (0.156)	
CUSUM	S		S		U	
CUSUMQ	S		S		U	

*, **, *** indicates statistical significance at 10%, 5% and 1% respectively
The Breusch-Godfrey LM Test (B-G LM) and Breusch-Pagan-Godfrey Heteroscedasticity (BPG) tests are used for serial correlation and heteroscedasticity respectively.
For CUSUM and CUSUMQ: S is stable and U is unstable

On the basic asymmetric model (Table 5.10: model 1), the long-run coefficient for overvaluation is negative and not statistically significant, whilst the coefficient for undervaluation is positive and significant (although marginally at a 10% level). On application of the Wald test, I fail to reject the null hypothesis of long-run symmetry between undervaluation and overvaluations in the manufactured exports demand equation. Turning to the second nonlinear model (model 2 inclusive of exchange rate volatility), the long-run coefficients for undervaluation and overvaluation are both negative, although only overvaluation is statistically significant at a 5% level. The coefficient for exchange rate volatility is also negative and significant at 5%, leading me to conclude that exchange rate overvaluation and volatility appear to wield a negative influence on South Africa's manufactured exports when considered together. This conclusion is similar to the one reached when considering aggregate exports. For a model that has volatility alone (i.e. without misalignment), and in line with the result from the aggregate exports model, I also fail to confirm cointegration amongst the variables entering the export demand equation and conclude that exchange rate volatility (based on the GJR-GARCH (1,1) model employed) on its own does not appear to influence South Africa's manufactured exports. As observed in Chapter 3, volatility measures are more efficient when looking at high frequency data. The fact that the study uses quarterly data might thus be another reason behind the conclusion reached.

In summary, the results from the study indicate that no meaningful relationship could be ascertained between a misaligned exchange rate (including overvaluation and undervaluation) and agricultural and mining exports since no meaningful cointegrating relationship could be determined between these variables. Moreover, there appears to be an asymmetric link between manufactured exports and exchange rate uncertainty (as represented by overvaluation, undervaluation and volatility), with both an overvalued exchange rate and exchange rate volatility having a negative influence on exports. Based on the results, exchange rate volatility on its own does not have an effect on South Africa's manufactured exports, although this effect is negative if taken together with exchange rate overvaluation. Previous studies (e.g. Sekantsi, 2011; Takaendesa *et al*, 2005) that apply monthly data in the analysis concluded that exchange rate volatility (on its own) exerts a negative influence on exports (to the United States).

5.6.3 Exchange rate hysteresis and exports: are thresholds of misalignment important?

Given the results above, and since not every movement in the REER is expected to influence exports, the analysis was extended to ascertain if there are thresholds that could influence the reaction of exports to exchange rate movements. The focus once again is on aggregate and manufactured exports. Starting with aggregate exports and considering exchange rate undervaluations (Table 5.11), the outcomes from the NARDL models suggest that an undervalued rand has no meaningful influence on aggregate exports, irrespective of the size of undervaluation. This is due to the fact that the coefficients for undervaluation from the various export demand models are not statistically significant and have different signs at different threshold levels. The findings are in line with the conclusion made when applying the series without thresholds, as an undervalued exchange rate was found to have a positive but not statistically significant influence on South African aggregate exports. Turning to the influence of an overvalued exchange rate, the coefficients for overvaluation are mostly negative (especially for large overvaluations) but also not statistically significant (Table 5.12), leading me to confirm as well that based on the sample data used in the study, the size of overvaluation is not important in explaining the impact on exports. Combining the overvaluation and undervaluation threshold levels in one model also produces mixed results (Table 5.13). At the large threshold level of 3% (i.e. overvaluation and undervaluation that exceeds a 3% threshold level), the coefficient for overvaluation is negative and statistically significant at a 5% level, with the coefficient for undervaluation positive and statistically significant at 10%. Results from other thresholds are mixed and inconclusive, thus allowing us to conclude that the size of misalignment does not appear to matter much currently in explaining the influence of exchange rate overvaluation and undervaluation on aggregate exports.

When considering the possibility of exchange rate hysteresis on manufactured exports, extending the NARDL model into two thresholds also does not improve the results. The bounds tests fail to confirm cointegration amongst the variables when applying the different thresholds of misalignment (Table 5.14 below). This finding is true for all models that consider either a single series of either overvaluation or undervaluation or a combination of both at the different threshold levels, thus allowing me to conclude that exchange rate hysteresis does not matter much. In conclusion, the results from the study indicate that South African exports (aggregate level and manufactured exports) appear to be negatively influenced by both an overvalued exchange rate and real exchange rate volatility, although the positive effects of an undervalued exchange rate are not evident. The study fails to confirm the existence of hysteresis in the reaction of exports to exchange rate misalignment, outlining a possible weakness in the relationship between exchange rate movements and South African exports. Compared to the conclusions reached in the previous chapter (misalignment and growth), where an undervalued exchange rate of around 10% was positive for growth, this raises the possibility that the main channel for transmitting exchange rate movements to economic performance might not be through exports, but other economic variables such as investment or employment. Exploring more possible channels for the influence of exchange rate misalignment to economic performance would be worthy additions to the literature.

Table 5.11: Undervaluation series alone (aggregate exports)

Misalignment Thresholds								
	3%		5%		7%		10%	
	large	small	large	small	large	small	large	small
Long run coefficient estimates								
LIP	2.173 (10.376)***	2.788 (2.108)**	2.176 (9.886)***	3.151 (2.054)**	2.174 (10.210)***	2.153 (9.377)***	2.157 (10.222)***	2.140 (9.595)***
LREER	-1.247 (-2.559)**	-0.885 (-0.783)	-0.789 (-1.881)*	-0.154 (-0.116)	-0.753 (-1.935)*	-0.970 (-2.834)***	-0.935 (-2.390)**	-1.013 (-3.017)***
LTOT	2.604 (7.708)***	1.893 (1.220)	2.744 (7.980)***	1.016 (0.418)	2.764 (8.786)***	2.649 (8.330)***	2.751 (8.615)***	2.666 (8.444)***
L-under_V	0.017 (1.059)		-0.006 (-0.604)		-0.008 (-0.886)		-0.001 (-0.119)	
S-under_V		-0.359 (-0.730)		-0.019 (-0.305)		0.006 (0.312)		0.010 (0.689)
ECM$_{t-1}$	-0.270 -6.165***	-0.079 -3.425***	-0.242 -5.245***	-0.090 -3.359***	-0.250 -5.286***	-0.229 -5.210	-0.253 -5.558***	-0.231 (-5.255)***
Bounds Test	6.019***	1.860	4.359**	1.786	4.427***	4.300**	4.889***	4.375***
B-G LM Test	1.272(0.285)	0.195(0.822)	1.084(0.342)	2.002(0.073)	1.028(0.361)	1.074(0.345)	0.335(0.716)	1.185(0.310)
BGP Test	1.080(0.383)	1.019(0.443)	1.045(0.418)	1.467(0.116)	0.995(0.469)	1.111(0.354)	1.119(0.344)	1.057(0.406)

*, **, *** indicates statistical significance at 10%, 5% and 1% respectively

The Breusch-Godfrey LM Test (B-G LM) and Breusch-Pagan-Godfrey Heteroscedasticity (BPG) tests are used for serial correlation and heteroscedasticity respectively.

Table 5.12: Overvaluation series alone (aggregate exports)

Misalignment Thresholds: Long-run coefficient estimates								
	Large	Small	Large	Small	Large	Small	Large	Small
	3%		5%		7%		10%	
LIP	2.681 (5.301)***	2.191 (9.183)***	2.189 (8.130)***	2.184 (9.037)***	2.212 (8.077)***	2.602 (5.105)***	2.368 (6.578)***	2.186 (9.3580***
LREER	-0.183 (-0.247)	-1.028 (-3.116)***	-0.912 (-2.248)**	-0.960 (-2.764)***	-0.883 (-2.186)**	-0.279 (-0.376)	-0.636 (-1.206)	-0.667 (-1.765)*
LTOT	2.055 (4.176)***	2.558 (7.370)***	2.627 (7.749)***	2.607 (7.518)***	2.612 (7.680)***	2.057 (3.603)***	2.341 (4.826)***	2.734 (10.693)***
L-Over_V	-0.001 (-0.067)		-0.001 (-0.180)		-0.004 (-0.449)		0.042 (1.875)*	
S-Over_V		0.064 (1.332)		0.010 (0.425)		-0.005 (-0.228)		-0.018 (-1.411)
ECMt-1	-0.170 -5.719***	-0.226 -5.475***	-0.227 -5.201***	-0.225 -5.216***	-0.226 -5.215***	-0.178 -5.476***	-0.189 -5.802***	-0.286 -5.770***
Bounds test	5.168***	4.749***	4.285**	4.310**	4.308**	4.726***	5.312***	5.282***
B-G LM test	1.402(0.223)	0.734(0.482)	1.083(0.342)	0.985(0.377)	1.020(0.364)	0.718(0.635)	2.086(0.062)	5.009(0.027)
BGP Test	1.732(0.044)	0.885(0.592)	1.093(0.371)	1.085(0.378)	1.246(0.245)	1.537(0.079)	1.669(0.050)	2.582(0.003)

*, **, *** indicates statistical significance at 10%, 5% and 1% respectively

The Breusch-Godfrey LM Test (B-G LM) and Breusch-Pagan-Godfrey Heteroscedasticity (BPG) tests were used for serial correlation and heteroscedasticity respectively.

Table 5.13: Combined overvaluation & undervaluation series[46] (aggregate exports)

	Misalignment thresholds							
	Large	**Small**	**Large**	**Small**	**Large**	**Small**	**Large**	**Small**
Long run	**3%**		**5%**		**7%**		**10%**	
LIP	2.542 (12.538)***	3.160 (2.030)**	2.340 (5.100)***	3.203 (1.985)*	2.602 (7.106)***	2.630 (4.805)	2.076 (9.988)***	2.178 (9.401)***
LREER	-0.806 (-2.272)**	-0.816 (-0.756)	-1.488 (-1.534)	-0.171 (-0.126)	-0.989 (-1.756)*	-0.239 (-0.306)	-1.048 (-2.265)***	-0.702 (-1.883)*
LTOT	2.670 (12.477)	1.565 (0.927)	2.016 (2.610)**	0.911 (0.349)	2.209 (4.577)***	2.033 (3.311)***	2.828 (8.944)***	2.743 (10.779)***
Over_V	-0.025 (-3.318)***	0.174 (0.932)	-0.014 (-0.877)	0.022 (0.326)	-0.019 (-1.716)*	-0.004 (-0.203)	0.034 (2.373)**	-0.019 (-1.470)
Over_V	0.023 (1.973)*	-0.319)	0.031 (0.961)	-0.026 (-0.360)	0.029 (1.317)	-0.005 (-0.194)	-0.001 (-0.081)	0.007 (0.710)
ECM$_{t-1}$	-0.397 -7.591***	-0.082 -3.843***	-0.165 -4.705***	-0.088 -3.375***	-0.236 -6.609***	-0.176 -5.482***	-0.257) -5.904***	-0.289 -5.816***
Bounds test	7.702***	1.985	2.978	1.529	5.850***	4.013**	4.675***	4.554***
B-G LM test	0.794(0.556)	0.755(0.472)	0.362(0.6969)	4.520(0.013)	1.133(0.340)	0.740(0.618)	1.013(0.367)	4.858(0.029)
BGP Test	1.442(0.111)	0.785(0.711)	1.056(0.406)	1.386(0.149)	0.948(0.534)	1.544(0.075)	1.576(0.072)	2.282(0.008)

*, **, *** indicates statistical significance at 10%, 5% and 1% respectively
The Breusch-Godfrey LM Test (B-G LM) and Breusch-Pagan-Godfrey Heteroscedasticity (BPG) tests were used for serial correlation and heteroscedasticity respectively.

5.6 CONCLUSION

The purpose of this essay was to examine the impact of REER misalignment on South African exports by applying the asymmetric autoregressive distributed lag (NARDL) technique of Shin *et al.* (2011). Results from the study indicate that South Africa's exports have a cointegrating relationship with foreign income, terms of trade, relative prices and exchange rate movements. At the aggregate level, the results confirm asymmetry as exports appear to benefit less from exchange rate undervaluation than they suffer from an overvalued exchange rate. The same observation is true for manufactured exports, with the results confirming no meaningful relationship between exchange rate misalignment and agricultural and mining exports. When considered together with misalignment, the results indicate that exchange rate volatility, estimated through a GJR-GARCH (1,1) model, has a negative impact on exports. Lastly, the study fails to find evidence of hysteresis in the relationship between a misaligned exchange rate and exports as it is concluded that the size of exchange rate misalignment does not matter much for South African exports currently. This finding is interpreted as confirmation that the relationship between South African exports and exchange rate movements is not strong such that other factors such as global demand conditions, domestic labour productivity, investment, supply constraints and macroeconomic stability could be more important as drivers of

[46] Short-run error correction coefficients results are not reported but could be provided on request.

export growth. Another possible causal factor for this weak relationship could be the possibility that South African exports (mainly manufactured exports) comprise a high proportion of parts and components that are also imported, with exchange rate movements therefore influencing both exports and imports. This generates another possible area for further research in the context of this study (i.e. the influence of exchange rate misalignment on imports or the trade balance). As noted by Verheyen (2013), aggregation bias should be kept in mind when one estimates export demand equations such that further analysis that looks at the influence of the rand's misalignment on disaggregated exports either by country or product could provide further insight. These issues are beyond the scope of the study and could form the basis for further research.

Table 5.14: Manufacturing: Combined overvaluation and undervaluation series[47]

	Misalignment thresholds							
	Large	**Small**	**Large**	**Small**	**Large**	**Small**	**Large**	**Small**
Long run	**3%**		**5%**		**7%**		**10%**	
LIP	0.797 (3.319)***	0.889 (2.506)**	2.433 (0.353)	-1.784 (-0.142)	-1.050 (-0.393)	-3.979 (-0.210)	0.316 (1.454)	1.030 (1.810)*
LREER	-0.803 (-1.228)	-0.329 (-0.949)	-2.238 (-0.301)	3.139 (0.171)	-0.252 (-0.148)	0.104 (0.033)	-1.141 (-1.911)*	-1.153 (-1.153)
LTOT	0.762 (1.905)*	0.905 (2.138)**	-0.968 (-0.133)	4.630 (0.246)	2.922 (0.925)	6.265 (0.286)	0.947 (3.301)***	0.458 (0.622)
Over_v	-0.001 (-0.029)	-0.002 (-0.056)	-0.028 (-0.239)	0.084 (0.165)	0.063 (0.605)	0.191 (0.236)	0.085 (1.851)*	-0.033 (-0.999)
Under_v	0.016 (1.055)	-0.100 (-0.930)	0.046 (0.273)	-0.812 (-0.187)	-0.001 (-0.008)	-0.433 (-0.235)	0.015 (1.149)	0.080 (0.980)
ECMt-1	-0.052 -3.411***	-0.043 -3.100***	-0.009 -3.183***	0.006 4.096***	0.020 4.303***	0.008 4.749***	-0.086 -3.664***	-0.039 -4.279***
Bounds test	1.570	1.298	1.372	2.240	2.486	3.01	1.762	2.406
LM test	0.802(0.451)	0.132(0.875)	1.753(0.178)	0.059(0.942)	0.878(0.419)	0.019(0.980)	0.262(0.770)	0.138(0.871)
White test	1.930(0.034)	1.631(0.100)	1.498(0.166)	0.931(0.558)	1.259(0.244)	1.013(0.458)	1.636(0.035)	1.306(0.163)

*, **, *** indicates statistical significance at 10%, 5% and 1% respectively
The Breusch-Godfrey LM Test (B-G LM) and Breusch-Pagan-Godfrey Heteroscedasticity (BPG) tests were used for serial correlation and heteroscedasticity respectively.

With overvaluation appearing to hurt exports more compared to the possible benefits that could be realised from undervaluation, when faced with exchange rate appreciation and overvaluation, the SARB could intervene in the foreign exchange market in order to limit further appreciation and align the currency closer to its long-run equilibrium levels. Such a policy would also help the SARB build foreign exchange reserves to anchor and promote the country's financial stability. Maintaining the exchange rate at a competitive level is also desirable as a measure to boost manufactured exports, although such a policy should be secondary to labour productivity and a good supportive infrastructure that allows manufacturers to produce at full capacity. As evidenced by the results from the first essay (Chapter 3), if exchange rate misalignment episodes are not a direct result of deliberate policy actions, the likelihood of exchange rate undervaluation boosting exports would be quite limited. The starting point is for the SARB to have a view on the level of the exchange rate that is supportive of both economic growth and exports, and acceptable inflation, and then steer the REER towards this level. Equally important are macroeconomic and political stability, as the absence of these key factors would discourage investments, thus making it impossible for the economy to react to positive global economic developments.

Appendix 2

Table 5.15: Descriptive Statistics – Chapter 5 Variables

	LEX	LY	LTOT	LREER	LMANUF	LMNG	LAGRI	MIS___	UNDER_V	OVER_V
Mean	8.038295	4.496866	4.453106	4.543899	12.57317	12.37119	10.89089	-0.016313	-2.453486	2.437173
Median	7.992037	4.590575	4.428433	4.561636	12.52855	12.36947	10.88731	0.546589	0.000000	0.546589
Maximum	8.968339	4.739077	4.650144	4.712768	12.87669	12.46326	11.24824	13.79928	0.000000	13.79928
Minimum	7.165525	4.119009	4.329417	4.209457	12.32729	12.27632	10.16942	-22.09738	-22.09738	0.000000
Std. Dev.	0.577387	0.199715	0.081476	0.110653	0.182866	0.035417	0.179283	6.572756	4.464630	3.347531
Skewness	0.177309	-0.502106	0.850559	-0.685360	0.291296	-0.184579	-0.587442	-0.802680	-2.388484	1.276161
Kurtosis	1.536142	1.694738	2.806435	2.970591	1.576449	3.296094	4.631712	4.036484	8.399841	3.548550
Jarque-Bera	11.05959	13.22174	14.28996	9.163731	11.53381	1.091752	19.70883	17.80097	253.3913	33.22438
Probability	0.003967	0.001346	0.000789	0.010236	0.003129	0.579334	0.000053	0.000136	0.000000	0.000000
Sum	940.4805	526.1333	521.0134	531.6362	1471.061	1447.430	1274.234	-1.908614	-287.0579	285.1493
Sum Sq. Dev.	38.67155	4.626773	0.770039	1.420321	3.879053	0.145503	3.728534	5011.330	2312.219	1299.892
Observations	117	117	117	117	117	117	117	117	117	117

Table 5.16: Granger Causality Test Results for Baseline Asymmetric Model

Pairwise Granger Causality Tests
Date: 01/16/18 Time: 05:28
Sample: 1985Q1 2014Q4
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ECT does not Granger Cause DLEX	115	4.05313	0.0200
DLEX does not Granger Cause ECT		0.02361	0.9767
OVER_V does not Granger Cause LEX	115	2.45292	0.0907
LEX does not Granger Cause OVER_V		0.60260	0.5492
UNDER_V does not Granger Cause LEX	115	5.94671	0.0035
LEX does not Granger Cause UNDER_V		1.14346	0.3225

Table 5.17: Pairwise Correlations: Chapter 5

Correlation t-Statistic Probability	LEX	LY	LTOT	LREER	LMANUF	LMNG	LAGRI	MIS___	UNDER_V	OVER_V
LEX	1.000000									

LY	0.894309	1.000000								
	21.43346	-----								
	0.0000	-----								
LTOT	0.666752	0.392137	1.000000							
	9.593881	4.571331	-----							
	0.0000	0.0000	-----							
LREER	-0.537522	-0.453314	-0.043630	1.000000						
	-6.835789	-5.453797	-0.468329	-----						
	0.0000	0.0000	0.6404	-----						
LMANUF	0.985168	0.867209	0.714163	-0.458118	1.000000					
	61.56934	18.67633	10.94111	-5.526842	-----					
	0.0000	0.0000	0.0000	0.0000	-----					
LMNG	-0.410703	-0.352104	-0.371881	0.238241	-0.394184	1.000000				
	-4.830498	-4.034244	-4.296093	2.630599	-4.599578	-----				
	0.0000	0.0001	0.0000	0.0097	0.0000	-----				
LAGRI	0.805236	0.660726	0.641451	-0.424939	0.805326	-0.457968	1.000000			
	14.56301	9.439447	8.966523	-5.034087	14.56765	-5.524557	-----			
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-----			
MIS___	-0.117843	-0.008703	0.173499	0.748391	-0.048963	0.242045	-0.113598	1.000000		
	-1.272595	-0.093333	1.889218	12.10025	-0.525699	2.675186	-1.226144	-----		
	0.2057	0.9258	0.0614	0.0000	0.6001	0.0086	0.2226	-----		
UNDER_V	-0.199834	-0.111653	0.150034	0.761676	-0.120005	0.169815	-0.144626	0.884788	1.000000	
	-2.187091	-1.204883	1.627355	12.60584	-1.296280	1.847899	-1.567420	20.36143	-----	
	0.0308	0.2307	0.1064	0.0000	0.1975	0.0672	0.1198	0.0000	-----	
OVER_V	0.035139	0.131825	0.140557	0.453585	0.063915	0.248763	-0.030157	0.783415	0.403541	1.000000
	0.377056	1.426110	1.522418	5.457902	0.686818	2.754264	-0.323549	13.51761	4.729704	-----
	0.7068	0.1565	0.1306	0.0000	0.4936	0.0068	0.7469	0.0000	0.0000	-----

CHAPTER 6:
SUMMARY OF FINDINGS AND CONCLUSION

6.1 INTRODUCTION

The aim of this thesis was to analyse the performance of the rand's REER with a focus on its misalignment and volatility, and the subsequent effects of both factors on economic performance and exports in South Africa. This chapter accordingly presents a summary of the main findings from the thesis with possible policy implications, areas for further research and some limitations of the study.

6.2 THE BEHAVIOUR OF THE REAL EFFECTIVE EXCHANGE RATE OF SOUTH AFRICA: IS THERE A MISALIGNMENT?

On application of cointegration methods in the BEER framework of Clark and MacDonald (1998), the study confirms the existence of a long-run equilibrium relationship between the rand's REER and economic variables that include the terms of trade, external openness, external capital flows and government expenditure. The Markov regime switching method (MSM) is used to indicate that the exchange rate frequently and sometimes sharply deviates from its long-run equilibrium level, resulting in either an under- or overvalued currency. The study finds evidence that the exchange rate was undervalued to different extents for much of the sample period, although movements in each direction were not quite persistent. Four overvaluation episodes were identified (1986-1988, 1997-1998, 2003-2006 and 2010-2012), with the study indicating that the exchange rate was undervalued (to differing extents) over most of the period studied. Extreme undervaluation in the exchange rate was recorded in the period 1998-2002 and during the midst of the global financial crisis in 2007-2008. Such findings are consistent with prior studies on the same subject (e.g. Saayman, 2010). As opposed to previous studies that mainly answer the question of whether the exchange rate is under- or overvalued, one contribution of this study to the literature is that the relative probability of under- against overvaluation of the rand was considered, and the likelihood of moving from one state to another in a regime switching context. Most importantly, a weak exogeneity test confirms that the REER is endogenous in the estimated equilibrium model.

The study hence identifies economic variables that form a long-run cointegrated movement with the rand's REER in South Africa (i.e. the terms of trade, external openness, government expenditure and capital flows). Should policymakers wish to use the exchange rate as a policy tool, one of the key pre-requisites for this is an understanding of the drivers of the equilibrium exchange rate such that any deliberate actions to deal with exchange rate misalignment would have to focus on the underlying fundamentals driving the exchange rate. For example, with net capital inflows associated with an appreciation in the exchange rate, when faced with exchange rate overvaluation, the SARB could consider either reducing interest rates or applying a temporal tax on capital inflows that are deemed to be short-term or volatile in an effort to drive a policy-induced depreciation in the exchange rate. The starting point, however, is for the SARB to formally acknowledge the REER as part of its policy toolkit and have a view on where the level of the exchange rate is relative to its equilibrium.

Although the study finds that the exchange rate is misaligned from time to time, it is important to note that these episodes are mainly abrupt and not policy-induced. Exchange rate undervaluation episodes have been in response to either idiosyncratic shocks emanating from internal economic challenges (e.g. the rand crisis of 2001) or systemic global factors (2007-2008 global financial crisis) that are transmitted through either the nominal exchange rate or capital flows. For an undervalued exchange rate to have a positive macroeconomic impact on exports, this misalignment has to be policy-induced such that a particular misalignment level is targeted and extreme movements are avoided, which has not been the case in South Africa. On the same note, one can also observe that exchange rate overvaluation episodes have coincided with good economic performance (e.g. between 2003 and 2006). When the economy is performing well, there is good scope for the central bank to initiate policy that will have the effects of weakening the exchange rate in an effort to support long-term export performance. However, such a policy would need to be consistent over time for the desired effects to be realised. The SARB normally indicates that it is concerned with exchange rate movements in as far as they influence the outlook for inflation under the current inflation targeting monetary policy framework. For a developing country such as South Africa with numerous economic challenges, there is reason enough to consider other variables such as the exchange rate as a further policy tool, although this has to be considered in the context of a broader set of macroeconomic policy initiatives. Another possible issue for the SARB to consider is whether the 3-6% inflation target band is appropriate under the challenging economic conditions facing South Africa. What if the target level was relaxed marginally to a 4-7% range, coupled with minimal exchange rate undervaluation? Further research in this area could be beneficial. Given the difficulty for a central bank to target both inflation and the exchange rate, an asymmetric exchange rate policy that seeks to avoid overvaluation whilst building foreign exchange reserves could be the starting point.

Exchange rate modelling and estimation of the equilibrium level of the exchange rate remain controversial and contentious in the empirical literature, an indication of the limitations associated with such research. Although the study is able to identify economic variables that have a long-run relationship with the exchange rate, as noted by De Jager (2012), the equilibrium level of the exchange rate is highly influenced by the choice of variables entering the exchange rate model. Important to note is the fact that most of the variables used to explain the equilibrium exchange rate of the rand are associated with the external sector (external openness, terms of trade and net capital flows). Although not entirely a problem given the fact that South Africa is a highly open economy, and the exchange rate is endogenous in the equilibrium model, it raises the possibility that the equilibrium exchange rate of the rand could be better explained using Williamson's (1993, 1994)

Fundamental Equilibrium Exchange Rate approach. This methodology emphasises the balance on the current account such that the equilibrium real exchange rate is the one that ensures the current account adjusts back to its norm over time. An extension of the study could use this approach to model the rand's misalignment over time and compare the results with findings from this study. Further research in this area could also focus on the application of different methods to estimate the equilibrium exchange rate (e.g. NATREX) and compare whether these approaches produce consistent misalignment estimates in South Africa. Since the study merely sought to measure whether the exchange rate was misaligned over time, another future area of research would be to determine the factors that drive such a misalignment within a regime-switching context. In line with Goldfajn and Valdés (1999), an investigation into the factors that drive the reversion of the exchange rate back to its long-run equilibrium level (via either nominal exchange rates or inflation differentials) in South Africa is also an area worth exploring.

6.3 MODELLING REAL EFFECTIVE EXCHANGE RATE VOLATILITY: EVIDENCE FROM SOUTH AFRICA

In the second essay (Chapter 3), motivated by the fact that most studies in the South African literature (e.g. Aye *et al.*, 2015; Sekantsi, 2011) apply different measures of volatility to evaluate its impact on macroeconomic factors, the thesis explored which method in the GARCH family of models correctly captures the volatility characteristics of the rand. Results from the study confirm that the GJR-GARCH (1,1) with the normal error distribution is the best fitting model for the rand's REER volatility compared to the ARCH, GARCH (1,1) and the EGARCH (1,1) models with in-mean and different error distribution assumptions. This model was able to accurately capture the significant increases in exchange rate volatility experienced in South Africa over the sample period, with such episodes of high volatility linked to the historical exchange rate depreciation experiences. Such a methodology can add value to the forecasting abilities of institutions such as the SARB, National Treasury and investors with exposure to the exchange rate either through international trade or investments. From a policy perspective, the challenge for the central bank is the ability to deal with the extreme volatility in the exchange rate as it has the potential to negatively influence investment decisions. One should note, however, that within the same context, South Africa has highly developed financial markets that offer good hedging products to investors and entities involved in international trade that could be employed to manage exposure to foreign exchange rate risk.

Although all GARCH model specifications used in the study indicate the ability to model the volatility of the rand's REER with the GJR-GARCH (1,1) identified as the superior model, one notable observation from the other models is the fact that the rand's volatility might be persistent or exhibit long memory characteristics. Akgul and Sayyan (2008) state that the presence of long memory in certain time series data (e.g. exchange rates) might imply that volatility estimates captured by ordinary and stable GARCH type models could be unsatisfactory. A worthy addition to the literature could be modelling the rand's exchange rate using long memory models such as the Fractionally

Integrated GARCH model (FIGARCH). A further possible limitation of this study is the fact that the exchange rate variable of interest (REER series) is only available on a monthly basis, whereas volatility modelling with ARCH/GARCH type methods produces the best results when applied to high-frequency data (daily or weekly series). The volatility estimates obtained in this study are further transformed into quarterly data for application in essays 3 and 4, and this might have influenced the limited impact of this variable on both economic performance and exports.

Worthy additions to the literature in a similar context could include modelling other financial market indicators including bond yields, short-term interest rates, yield spreads, credit default swap spreads and commodity prices in the South African context. Since the study applies only three variations of the GARCH model, other approaches within the GARCH family (e.g. the Asymmetric Power GARCH (APARCH), the Fractionally Integrated GARCH (FIGARCH) and the Hyperbolic GARCH (HYGARCH)) could be used to assess whether they perform better than the JGR-GARCH (1,1) model.

6.4 EXCHANGE RATE MISALIGNMENT, VOLATILITY AND ECONOMIC GROWTH IN SOUTH AFRICA

The third and fourth essays (Chapters 4 and 5) contribute to the empirical literature in several ways. Firstly, the studies assess the influence of exchange rate misalignment on economic growth and exports, a subject largely ignored in the South African context. Secondly, the key focus is on asymmetry in the possible reaction of exports and growth to exchange rate misalignment (i.e. whether the exchange rate is over- or undervalued, together with the size of such misalignment). Lastly, the study considers misalignment and volatility as two measures of exchange rate uncertainty such that they are not considered in isolation to each other. The study hence brings in a new dimension to the literature by making a comparison as to whether it is exchange rate misalignment or volatility, or a combination of both, that influences South African economic activity and exports.

The results allow me to confirm that there are asymmetric effects of exchange rate misalignment on economic growth in South Africa, with exchange rate undervaluation of approximately 10% being positively correlated with economic growth. Although not statistically significant, the results show that exchange rate overvaluation has a negative influence on economic performance. The results (although admittedly not very robust) indicate that an argument can be made for maintaining the exchange rate at a slightly undervalued level as one of the attempts to boost economic performance. Such findings are consistent with conclusions made from previous studies (e.g. Rodrik, 2008a, Wong, 2013). The muted response of economic growth to exchange rate undervaluation could be due to the fact that misalignment episodes observed in the study have been erratic and mainly attributable to shocks to the exchange rate, unlike what can be observed in countries such as China where the authorities deliberately target a particular exchange rate level. The SARB could therefore consider using the exchange rate as a further policy tool, although this would still have to be within the broader inflation targeting policy framework. Lastly, REER volatility as specified through a GJR-

GARCH (1,1) model is not found to have an influence on real GDP. The major limitation of the study is with regard to the difficulty in empirically estimating growth models. Some limitations that should be noted from the study include the insignificance of the volatility variable, which could be attributed to the volatility modelling approach employed. Different GARCH models that either take into account long memory or structural breaks (e.g. Babikir *et al*, 2012) could be a worthy addition to the literature. Although the study finds a positive link between exchange rate undervaluation and economic performance, more channels through which the relationship is transmitted need to be explored.

Another caveat is the fact that the results are dependent upon the misalignment series obtained through the BEER framework employed earlier, whereas there are other approaches to modelling the equilibrium exchange rate and misalignment. Using a different model to estimate misalignment therefore has the potential to yield different results.

6.5 EXCHANGE RATE MISALIGNMENT, VOLATILITY AND EXPORTS IN SOUTH AFRICA

On exports, the study finds that South Africa's aggregate exports benefit less from an undervalued exchange rate than they suffer from an overvalued exchange rate. The same observation is true for manufactured exports, while the results confirm no meaningful relationship between exchange rate misalignment and agricultural and mining exports. Regarding volatility, the conclusion is that volatility exerts a negative influence on exports only when considered together with misalignment. The finding implies that the negative influence of exchange rate overvaluation is compounded by the volatility of the exchange rate such that policy actions directed at limiting exchange rate volatility would be ideal. This is also true for manufactured exports where exchange rate volatility on its own does not have an effect on South Africa's manufactured exports, although this effect is negative if taken together with exchange rate overvaluation. Regarding the size of misalignment (both over- and undervaluation), based on the sample data, the study fails to confirm evidence of hysteresis in the reaction of exports to exchange rate misalignment for both aggregate and manufactured exports. The results from the study provide credence to the view that maintaining the exchange rate at an appropriately competitive level is desirable as a measure to boost manufactured exports, although such a policy should be secondary to labour productivity, a good supportive infrastructure that allows manufacturers to produce at full capacity, and macroeconomic stability and political certainty. This finding is consistent with the confirmation of an asymmetric impact of exchange rate misalignment on growth, with undervaluation being positive but overvaluation negative.

Although the study was able to confirm asymmetry such that undervaluation is positive for both exports and growth, and overvaluation likewise impedes exports and growth, it is important to note that such results are not fully satisfactorily robust. For example, on the topic of economic growth and misalignment, although the coefficient for overvaluation in the models is negative, the results are not statistically significant. On exports and misalignment, the coefficients for undervaluation are indeed positive but also not statistically significant, confirming that with such results the relationship is not strong enough. One possible explanation for this is that exchange rate misalignment is not quite persistent in South Africa, with the exchange rate quickly moving from one episode to another. Furthermore, past exchange rate misalignment episodes have been in response to economic shocks as opposed to policy actions of the SARB. Countries that have successfully used mercantilist policies to foster exports and growth (e.g. China) have had prolonged policy-induced periods of an undervalued currency such that there is enough time for economic agents to respond to such policy initiatives. This corroborates the view that the SARB could consider adding the level of the REER as one of its policy tools. This could go together with efforts to intervene in the markets, where appropriate, to limit excessive exchange rate volatility since uncertainties negatively influence exports. This has to be considered with caution as well since an undervalued currency could have negative undesired effects such as high inflation when accompanied by macroeconomic instability. For countries in the common monetary area (Namibia, Lesotho and Swaziland, whose currencies are pegged on a 1-1 basis to the South African rand), there is a continuous need to assess the macroeconomic impact of the rand's movements in order to ascertain if the exchange rate policy still meets the desired objectives. A possible key topic for future research in this area is to consider the influence of exchange rate misalignment on investment, since this could be a direct channel through which exchange rate movements influence the economy, as opposed to exports. One final limitation of the study is the lack of credible data on South African exports at sector levels, hence gross economic value added from the different sectors was used as proxies for exports. Depending on the availability of actual sectorial exports data, this is one key area of improvement recommended for future analysis.

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