The behaviour of the real effective exchange rate of South Africa: Is there a misalignment?

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Abstract

The Behavioural Equilibrium Exchange Rate method is applied to estimate the equilibrium real effective exchange rate of the rand and establish whether the observed exchange rate is misaligned from this equilibrium level. The exchange rate's misalignment behaviour is further explored using a regime switching model. Results confirm the existence of a cointegrating relationship between the exchange rate and terms of trade, external openness, capital flows and government expenditure. The study confirms that the exchange rate is misaligned from time to time with the Markov regime switching model correctly capturing the misalignment as alternative shifts between overvaluation and undervaluation episodes.

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I. Introduction

The exchange rate remains arguably one of the closely watched economic indicators by policymakers, financial market participants and industries involved in international trade as it reflects a country's competitiveness in international markets and thus has a major influence on economic activity. Exchange rate misalignment, a situation where the exchange rate deviates from its long run equilibrium level resulting in either an overvalued 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 evidence in the literature to suggest that keeping the exchange rate close to its equilibrium level is a necessary pre-condition for growth, with countries that avoid currency overvaluation linked with export-led economic growth and export diversification (Elbadawi et.al, 2012).

In recent years, some countries (e.g. China) have been accused of pursuing 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 economic imbalances that feed economic instability, contributed to the 2007-2008 global financial crisis and continue to impede recovery from the crisis (see Holtemoller and Mallick, 2013; Lòpez-Villavicencio et.al, 2012; Cheung and Fujii, 2014). Although an undervalued exchange rate can be supportive of economic growth, an overvalued currency on the other hand has the potential to undermine export competitiveness, causing an unsustainable current account deficit and lower economic growth. There is a compelling need for emerging markets, especially those with open economies and liberal capital accounts to continuously assess the behavior of the exchange rate and ascertain whether their currencies are either overvalued or undervalued, what the likelihood of a change in the state of the currency is and the key factors that drive movements in the exchange rate over time.

The South African rand has experienced considerable variations over the past three decades covering cycles of appreciation and subsequent declines. Over this period, the country has gone through different exchange rate regimes with policy mainly shifting from a managed float to a freely floating exchange rate system. Fattouh et.al (2008) observe that South Africa has undergone numerous structural shocks and changes in the economic system since the late 1970s that include amongst others; foreign capital "sudden stops" in the midst of the apartheid regime, a debt default, the 1994 democratic transition, abolition of exchange controls, trade and currency liberalization, global financial market liberalization and the most recent global financial crisis. Such developments are most likely to have influenced the movement of the exchange rate and its behaviour relative to economic fundamentals.

Debate about the equilibrium level of the rand and the factors driving the currency is ongoing with a lack of consensus on the level of the exchange rate consistent with the country's economic fundamentals. South Africa is a small open economy highly vulnerable to global trade and capital flow patterns. Under the current context of global imbalances and the role of countries like China (whose role is increasing as South Africa's major trading partner), exploring the issue of currency misalignment is important for the country. Other challenges that the country faces that have possible implications for exchange rate movements include a chronic current account deficit, de-industrialization and a declining manufacturing sector (% contribution to GDP), anaemic economic growth and a high unemployment rate. The New Growth Path Framework (2011), which provided government's blue print for economic growth and job creation, makes a call for a more competitive exchange rate that should support government's initiatives, providing an indication that policy makers have interest in the level of the exchange rate that should support economic growth.

Considering this background, the aim of this study is to estimate the extent to which the rand's real effective exchange rate (REER) is misaligned from its equilibrium level. This is achieved through using 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 REER misalignment. In a similar fashion to Terra and Valladares (2010), a Markov regime switching method (MSM) is then applied to quantify whether the exchange rate's departure from the equilibrium level is meaningful enough to be considered as either overvalued or undervalued. As opposed to previous studies which mainly answer the question of whether the exchange rate is undervalued or overvalued, this study considers the relative probability of undervaluation against overvaluation and the likelihood of moving from one state to another in a regime switching context.

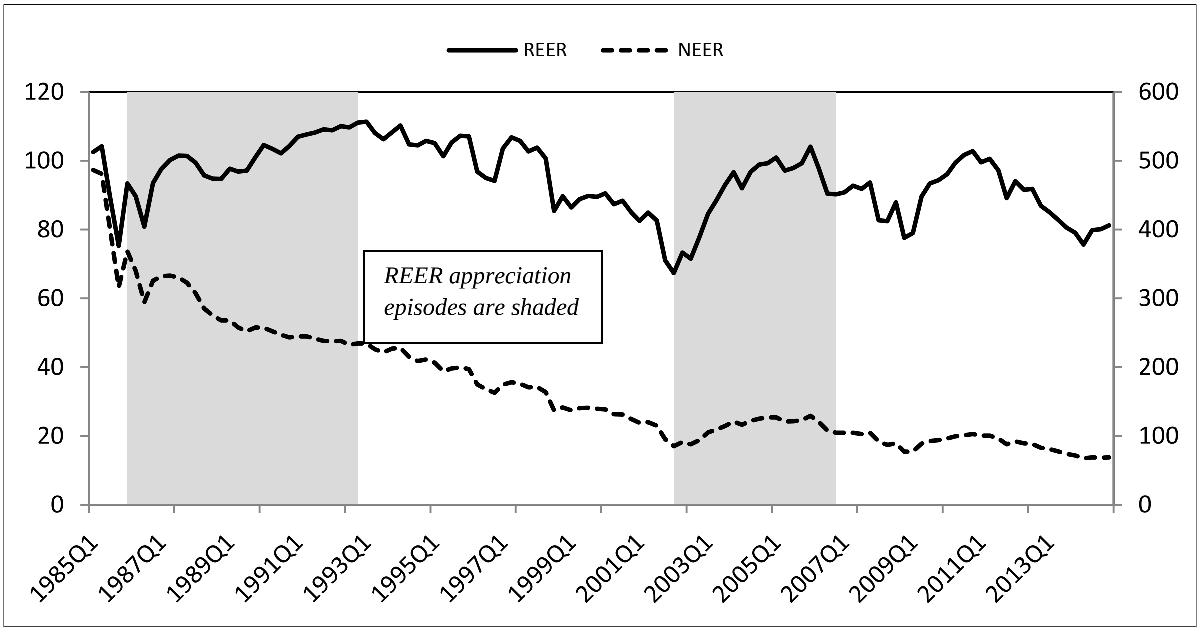
The main findings from the study are the following; firstly, the variables; terms of trade (including gold), external openness, capital flows and government expenditure form a long-run cointegrating relationship with the exchange rate (REER) and are used to estimate the equilibrium level of the currency. Secondly, the rand is misaligned (deviates sharply) from its long-run equilibrium level from time to time with the rand undervalued in the range of -0.96 to -7.66 percent between 2013 and 2014. The highest level of undervaluation is observed in 2002Q1 (-22.10%) and the maximum point of overvaluation is realized in 2006Q1 (13.80%). Thirdly, the Markov regime switching model provides an appropriate framework for modelling exchange rate misalignment since the movement of exchange rate gravitates between two regimes of undervaluation and overvaluation.

The rest of the paper is structured as follows; section II provides a historical background of the rand's movements together with a selection of the country's economic indicators. Section III presents the theoretical foundation of REER estimation. A review of relevant previous studies on exchange rate modelling is also presented in this section. The empirical method applied is provided in IV with the results presented in section V. Conclusion and policy implications are provided in VI.

II. Exchange rate performance in South Africa

South Africa's foreign exchange policy has evolved over the past 30 years with policy broadly moving 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 and Rogoff, 2002). From the early 1970's to the year 2001, 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 influence the direction of the rand within a broader eclectic monetary policy 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 NEER and REER) is represented below in Figure 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 and movements in the exchange rate also indicating the presence of volatility. Between 1985 and 2014, about four currency episodes[3] can be identified; two appreciation periods and an equal number of depreciation episodes (figure 1).

Figure 1: Rand REER and NEER historical performance



Data source: South African Reserve Bank

In the early 1980s up until pre-1994 democratic elections, the political tensions in the country, 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

[3] An episode for the purposes of this study 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 most likely to cause the exchange rate to be undervalued.

positive balance on the current account (table 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 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 democratic transition in 1994. Factors that include possible contagion from the Asian financial crisis, low global commodity prices and speculative attacks on the currency caused a severe depreciation in the currency. The extent of currency depreciation over this period raised questions as to whether this was a temporal deviation of the rand from it's from the equilibrium level (MacDonald and Ricci, 2004).

The currency recovered sharply from the end of 2001 resulting in an appreciation episode from 2002 until 2006 where the real effective exchange rate strengthened by around 34%. This episode was driven by an appreciation in the nominal exchange rate and declines in the inflation rate. The extent and speed of the recovery in the rand suggests that the currency might have been highly undervalued in 2001 thus necessitating a correction. Saayman (2007) notes that the rand's appreciation in 2002 created concerns about the competitiveness of South African exports from the mining houses and labour unions. This raised calls and exerted pressure on the South African Reserve Bank to weaken the currency in an effort to boost exports and employment creation. The Manufacturing Circle (Manufacturing Bulletin, December 2010) cited the appreciation of the rand (trend) and its volatility as one of the principal drivers of the country's observed de-industrialization process and argued that a competitive exchange rate would boost the productive capacity of the export sector.

The inception of the global financial crisis in 2007 and the subsequent collapse in global trade flows, decline in economic performance and increase in global financial market volatility (especially risk perception towards emerging markets like South Africa) had a major impact 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 real effective exchange rate depreciated gradually from 2010 to end 2014 at 81.20. Such developments, especially the extent of the weakness in the nominal exchange rate, raised concerns again about whether such movements reflect South Africa's economic fundamentals and the currency was correctly priced or this signified a misalignment in the exchange rate. Against this background, it is also worthy to note that the country faces a current account deficit that has been increasing over the years, a decline in the manufacturing sector's contribution to GDP, an improving terms of trade position and a higher increase in imports as a percentage of GDP as compared to exports (table 1 below). All these factors are likely to help explain the developments in the real effective exchange rate over time.

Table 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: South African Reserve Bank

III. Theoretical framework and literature

a. 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 real effective exchange rates. Driver and Westaway (2004) in a comprehensive review of the different methodologies that have been applied to real effective exchange rate estimation, note that different theoretical measures of the real effective exchange rate 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 normal starting point for equilibrium exchange rate estimates and relies on relative prices as the key driver of exchange rates (Aflouk et.al, 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 et.al, 2014) and a country's currency should purchase the same basket of goods and services in the 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; i.e. exchange rates fail to converge to a constant mean (Saayman, 2007; Driver and 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 equilibrium exchange rate which postulates that exchange rates are driven by the relative excess money supply across countries (MacDonald, 2000). Driver and Westaway (2004:35) 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 IMF's Consultative Group on Exchange Rate Issues (CGER) identifies three approaches to equilibrium exchange rate determination which are backed by different theoretical underpinnings. These are: the *Macroeconomic Balance Approach; the Equilibrium Real Exchange Rate Approach and the External Sustainability Approach,* (Bussière et.al, 2010; Ajevskis et.al 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 (FEER) (Bussière et.al, 2010). These approaches put emphasis on 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 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 utilization 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 real exchange rate (BEER) whereby the real effective exchange rate 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 (2006:4) 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.

On a broad level, the estimation of equilibrium exchange rates have therefore taken theoretical approaches either based on 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). Lòpez-Villavicencio et.al (2012:60) state that despite the conceptual differences, FEER and BEER methodologies rather complement one another instead of being substitutes. The BEER approach is the preferred approach for the study for its practical approach to equilibrium exchange rate estimation and ease of application to developing countries (Gan et.al, 2013). A major shortcoming of the fundamental equilibrium exchange rate 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 highly statistical and free of normative judgements.

The principal idea behind the BEER model is to empirically establish a long-run relationship between economic indicators and the exchange rate. Such a relationship would provide a baseline estimate of the equilibrium real effective exchange rate that can be used to assess the extent of misalignment in the observed REER. A reduced-form equation that explains the real effective exchange rate as a function of a set of fundamental variables is applied such that the REER is an endogenous macroeconomic variable whose behaviour is explained by non-stationary fundamentals (Panday, 2014). The real Uncovered Interest Parity condition (UIP) represents the starting point for BEER analysis (Siregar, 2011; Driver and Westaway, 2004) as follows:

$$q_t = E_t(q_{t+1}) - (r_t - r_t^*) \qquad [1]$$

Where the observable real effective exchange rate q_t is a function of the expected real effective exchange rate $E_t(q_{t+1})$ and the current real interest rate differential $(r_t - r_t^*)$, with r_t representing the domestic real interest rate and r_t^* the foreign real interest rate. BEER methodology postulates that the expected real effective exchange rate $E_t(q_{t+1})$ is determined by a set of long run economic fundamentals (Z_t). The BEER method therefore implies that long run economic fundamentals ($E_t(q_{t+1}) = f(Z_t)$) and short-run interest differentials ($r_t - r_t^*$) determinate the equilibrium exchange rate as follows:

$$q_t^{REER} = f(Z_t, (r_t - r_t^*)) \qquad [2]$$

Several variables are identified in the literature as the long run determinants of the vector (Z_t) and such include the terms of trade (*tot*), productivity differentials (*prod*), external openness (*open*) and government expenditure (*govt*). The BEER exchange rate could therefore be determined by the following specification:

$$BEER = f((r_t - r_t^*), tot, prod, open, govt)) \qquad [3]$$

Departure in the observed exchange rate from the one determined by fundamentals would therefore represent a misalignment in the exchange rate. Such misalignment would therefore be estimated as the difference between the observable or prevailing exchange rate (q_t) and the BEER real effective exchange rate (q_t^{REER}).

b. Review of related literature

Empirical literature on exchange rate modelling and the extent of real effective exchange rate misalignment is abundant. With exchange rate valuations at the centre of the global external economic imbalances, considerable work has been done on exchange rates for nations like China given the country's purported export-led growth strategy based on currency management. Given the wide-ranging nature of the literature, the brief review presented is not exhaustive and focuses mainly on the studies that are relevant for the paper through either the methodology used or an application of South African data[4]. One such study is Holtemoller and Mallick (2013) who use a sample of 69 countries to model the long-term equilibrium relationship between the REER and its key macroeconomic determinants. Applying data from 1970 to 2006 in a BEER framework, the authors are able to identify macroeconomic variables (terms of trade, the current account, the country's openness, GDP and exchange rate regime) that reveal a long-run relationship with the REER and interpret movements away from the equilibrium level as misalignment. A notable finding by the authors is that the nature of a country's exchange rate regime has an impact on the extent of currency under or over-valuation with highly flexible currencies showing lower misalignment dynamics. It is concluded in the study that high misalignment (that is also supported by low currency flexibility) can help cause a currency crisis such that policymakers need to be aware of the extent of a currency's misalignment and the potential contribution to a currency crisis that exchange rate misalignment poses.

Baak (2012) uses the Johansen (1995) Vector Error Correction Method (VECM) to show that economic variables including the terms of trade, net foreign assets, real interest rate differentials and the relative price of non-traded to traded goods explain the equilibrium level of the Korean won. The study finds that the exchange rate deviates from its equilibrium level from time to time with the Korean won undervalued by close to 20% before the troughs of both the 1997 (emerging market) and 2008 (global financial) crisis. Given the growing interest in recent years on exchange rate policy for the Chinese Renminbi, Gan et.al (2013) employ a reduced form BEER model (also in a VECM framework) to estimate China's long run equilibrium exchange rate and the direction and extent of its misalignment. Their study (1999-2007) finds modest misalignment in the exchange rate from an equilibrium level determined by openness, government spending, productivity and money supply. Other international studies that use BEER methodology to assess exchange rate misalignment include Mourougane (2012) for Brazil, Pattichis et.al (2007) on the Cypriot pound and Ibarra (2011) on the Mexican peso. Authors like Lòpez-Villavicencio et.al (2012); Clark and MacDonald (1998); Iman and Minoiu (2011) and Mourougane (2010) compare the performance of BEER and FEER methodology in their estimation of equilibrium exchange rates.

As opposed to most studies that use a Vector Error Correction Model (VECM) to estimate the equilibrium exchange rate and its extent of misalignment, Goldfajn and Valdes (1999) employ a combination of cointegration and Stock and Watson (1993) univariate methods to study appreciation episodes and the path of reversion back to equilibrium for a sample of 93 countries (including South Africa) over the period 1960 to 1994. It is argued in the study that using the Johansen method to estimate the cointegrating vector might be inappropriate since the approach is sensitive to any misspecification in the system whilst the Stock and Watson methodology corrects for possible serial correlation of residuals whilst catering for possibly endogenous fundamentals. Cointegration regressions drawn from variables

[4] A summary of selected studies on exchange rate modelling that influenced the study is presented in table 2 below.

that include terms of trade, size of government expenditure, external openness and international interest rate differentials are used to determine the equilibrium level of the exchange rate and the departures from such. Goldfajn and Valdes (1999:255) conclude that appreciation episodes last longer in the build-up phase than in the return phase and real exchange rate appreciation is normally corrected through nominal exchange rate devaluations as compared to domestic price adjustments. As the authors used pre-defined thresholds to identify the beginning and end points of appreciation (misalignment) episodes, the main shortcoming of this approach is that the thresholds used were arbitrarily determined.

Terra & Valladares (2010) seek to improve on Goldfajn and Valdes (1999) by using a Markov switching model to assess exchange rate misalignments episodes following the identification of cointegrating vectors between the exchange rate and a set of macroeconomic indicators. The main contribution of their method is that the Markov Switching model does not rely on one's discretion to assess whether the departure of the exchange rate from equilibrium is large enough to be considered an appreciation or depreciation episode (Terra & Valladares, 2010:120). Using data from 1960 to 1988 on a sample of 85 countries, the study finds that both the number and average length of misalignment occurrences are higher as compared to the results by Goldfajn and Valdes (1999). This could be attributed to the fact that the regime switching method endogenously determines the threshold that identifies appreciation and depreciation episodes as the behaviour of the series changes over time. Such a method is found to be appealing in the sense that it provides the relative probability of the exchange rate being either overvalued or undervalued regardless of the extent or magnitude of possible misalignment. This study will build upon the work of Terra and Valladares (2010) with a specific focus on South Africa. Several economic indicators that can likely explain the long-term movements of the real effective exchange rates are explored for possible inclusion in the cointegration equation.

Concerning studies that are specific to South Africa, Aron et.al (1997) is 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-run and short-run determinants of the real exchange rate within the macroeconomic balance approach. The study concludes that the exchange rate is a function of variables like 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 system. With regards to observed exchange rate misalignment episodes, their study finds that it would require 0.85 years to eliminate 50% of a misalignment in the exchange rate.

MacDonald and Ricci (2004) use the BEER method within a VECM framework to estimate a long-run cointegrating relationship between the real effective exchange rate and various economic variables over the period 1970 to 2002. They conclude that long-run real exchange rate movements in South Africa could be explained by commodity price movements, productivity, 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 are 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 state that deviations from the equilibrium exchange rate would normally be eliminated within a short period of time if there are no other shocks (8% speed of adjustment in the cointegrating equation) to the system.

Du Plessis (2005) raises the important issue of exogeneity 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 (2005:743) 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 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 argued 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 behavioural equilibrium exchange rate using three different measures of the real exchange rate (price inflation; cost inflation and labour cost adjusted real exchange rates). Also applying a VECM model, the idea was to ascertain how the different real exchange rate measures would influence the equilibrium long-run exchange rate and the extent of misalignment. Using relative GDP rates, 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 as explanatory variables, the author finds that the equilibrium exchange rate follows a similar path irrespective of the specification of the real exchange rate. In a more recent paper, Saayman (2010) uses BEER methodology in a panel data approach to identify the determinants of the long-run equilibrium rand exchange rate and episodes of exchange rate misalignment. Data from South Africa, together with the country's major trading partners (the EU, UK, Japan and US) is used in the panel with figures from 1999 to 2008. The study finds episodes of both over and undervaluation of South Africa's equilibrium exchange rate although the currency would revert back to equilibrium within a short period. Both studies by Saayman focus on bilateral real exchange rates as opposed to the real effective exchange rate which is more reflective of the country's external competitiveness.

A recent study by De Jager (2012) follows the BEER approach and also applies a vector error correction model to examine the various economic indicators that have an influence on the real effective exchange rate. The paper further seeks to model the real equilibrium 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, 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 real effective exchange rate can deviate from its equilibrium level and confirms 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 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 specified as suggested by Du Plessis (2005).

Table 2: Selected studies on exchange rate modelling in RSA

Author(s)	Period	Exchange rate measure	Method	Variables*	BEER 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	TP-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	Bilateral 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

*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), M2 (money supply), GOLD (gold price), RISK (country risk indicator), GDP (relative GDP)

Balcilar et.al (2014) apply a time-varying parameter VAR to study the relationship between the rand's real effective exchange rate and a given set of economic fundamentals. Although not specific to REER misalignment, the authors emphasize the role played by regime shifts in analysing the relationship between the exchange rate and economic fundamentals as their study finds that such relationship has changed over time. With the exchange rate decoupling from economic fundamentals from 1995 up to the 2007/08 global financial crisis, the authors state that other non-fundamental shocks might be responsible for explaining exchange rate behaviour. Balcilar et.al (2014) note that accounting for significant regime changes in South Africa and their impact on the exchange rate (e.g.1994 democratization, different monetary policy regimes, and quantitative easing by the major global central banks) would be worth exploring.

A Markov switching cointegration model is used by Fattouh et.al (2008) to indicate that the long run equilibrium exchange rate of the rand is explained by only three variables; nominal interest rate and inflation differentials (only USA and South Africa) plus the gold price. The study identifies two regime shifts (1984-86 and 2001-07) with the withdrawal of credit lines by foreign institutions explaining the first regime and the commodities supper cycle explaining the second regime (Fattouh et.al, 2008). The study does not consider other variables (e.g. terms of trade, external openness, capital flows) that might have an impact on the exchange rate. With their data only extending to 2007, their study also does not fully capture the effects of the 2007/08 global financial crisis which introduced an era of ultra-loose monetary policy across the world and capital flows towards countries like South Africa which had several implications for exchange rate movements. Lacerda et.al (2010) also use a Markov switching model to test for the purchasing power parity (PPP) and uncovered interest parity (UIP) conditions in South Africa under the presence of regime shifts. Their study shows that the Markov switching methodology supported the PPP and UIP conditions and confirmed that the effects of changes in monetary and exchange rate policies are important in modelling exchange rate behaviour as opposed to a linear VECM model.

The literature indicates that previous studies on exchange rate modelling in South Africa have mainly concentrated on the bilateral and real nominal 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 the country has also experienced several structural changes over the past few years, it is also likely that the economic fundamentals that determine the equilibrium exchange rate would shift accordingly, further motivating the importance of this study. The only limited studies that consider REER equilibrium levels and exchange rate misalignment apply similar methodology (linear cointegration methods) with all of them (except for De Jager, 2012) using data that dates before 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. Non-linear 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, regime switching methodology that captures these characteristics might be more appropriate to model such behaviour.

This study therefore adds to the literature in the following aspects: firstly, we apply more recent data 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 non-linear 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), we have 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; overvaluation 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) 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*".

IV. An empirical model of the real effective exchange rate

Following previous studies such as Goldfajn and Valdes (1999) and Terra and Valladares (2010), the empirical approach applied in the study entails using cointegration techniques to estimate a long run relationship between economic fundamentals and the real effective exchange rate (BEER framework); the construction of a misalignment series as the deviation of the observed REER from its predicted values and lastly; employing a Markov regime switching method to model the behaviour of the misalignment series. The data used in the study is from 1985 to 2014 and mainly captures the post-democratization period associated with an increased integration of South Africa with the global economy and highly liberal economic policy.

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 real effective exchange rate and subsequently modelling the exchange rate in a behavioural context. The reduced-form equation of the real effective exchange rate may be expressed as follows (Baak, 2012; Gan et.al, 2013):

$$LREER_t = \beta' F_t + \epsilon_t \qquad [4]$$

Where $LREER_t$ (log of) is the equilibrium real effective exchange rate, 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. The common variables that enter the vector (F) in the literature include proxies for productivity differentials (PROD), terms of trade (TOT), external openness (OPEN), the real interest rate differential (INT), government expenditure (GOV), commodity prices (COMM), and capital flow variables (CAP). Since we are dealing with non-stationary time series, the Johansen (1995) cointegration procedure is used to estimate the long-run relationship amongst the series. The following equation could therefore be estimated to compute the equilibrium real effective exchange rate;

$$LREER_t = a + \beta_1 PROD + \beta_2 TOT + \beta_3 OPEN + \beta_5 GOV + \epsilon_t \qquad [5]$$

Equation 5 captures a steady relationship between the exchange rate and the economic fundamentals (Saayman, 2007). After the identification of a cointegration equation and confirmation that exchange rate is endogenous in the long-run model, a single equation model is then used to estimate the cointegration relationship. In line with Goldfajn and Valdes (1999), the Dynamic Ordinary Least Squares methodology (DOLS) advocated by Saikkonen (1992) and Stock and Watson (1993) is applied to estimate equation [5] above. 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 and Valdes, 1999:234). The DOLS equation is specified as follows:

$$LREER_t = \beta F_t + \sum_{j=-k_1}^{k_2} \gamma_i \Delta F_{t-j} + e_t \qquad [6]$$

Where $LREER_t$ is the dependent variable (real effective exchange rate), F_t the vector of explanatory variables, k_1 and k_2 the numbers of leads and lags respectively. The stationarity of the residuals (ϵ_t) confirms the presence of cointegration with the order of the leads and lags consistent with the number of lags identified in the cointegration equation *[5]*. 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:

$$Mis_t = LREER_t - \underline{LREER_t^*} \qquad [7]$$

Where $\underline{LREER_t^*}$ represents the estimated equilibrium REER from equation [6]. 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.

4.2 Markov-switching model and REER misalignment

Hamilton (1989) proposed the Markov switching model applicable 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, 2008:466).The model assumes there exists k regimes or states of nature in the data generating process (e.g. 2 exchange rate episodes in the current study: overvaluation and undervaluation), normally distributed with mean μ_i and variance σ^2_i (different means and variances; μ_1, σ^2_1 in regime 1 and μ_2, σ^2_2 in regime 2 for a process with 2 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 et.al, 2010):

$$Y_t = a_1 S_t + a_2(1 - S_t) + [\sigma_1 S_t + \sigma_2(1 - S_t)]\epsilon_t \quad \text{where } \epsilon_t \sim N(0,1) \qquad [8]$$

Where Y_t is the variable of interest (exchange rate misalignment series in the study); 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 2 regimes would have the following transition probabilities (see Engel and Hamilton, 1990; Brooks and Persand, 2001):

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

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 us to estimate the probability that the exchange rate's misalignment series was at a given regime (undervalued or overvalued) at any point in time. Important parameters of the model that require estimation are μ_1, μ_2, σ^2_1, σ^2_2, p_{11} and p_{22} and 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 unobservable, inferences about their odds are based on the observed data. The algorithm chooses the parameter values in a manner that maximizes the log-likelihood function for the observed series (Bazdresch and Werner, 2005).

Following previous studies (including Engel (1994); Pinno and Serletis (2007); Nikolsko-Rzhevskyy and Prodan (2012), the exchange rate's behaviour (precisely the misalignment series in this study) is modelled as a 2-state Markov switching random walk model that allows both the drift term and variance to take two different values during episodes of overvaluation and undervaluation. This permits us to model exchange rate misalignment in any given quarter as being drawn from one of the two regimes and the parameter estimates can then be used to infer as to which regime the exchange rate is at. Terra and Valladares (2010) note that 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 undervaluation to an overvaluation regime; and *Pou* the likelihood of transition from overvaluation to undervaluation.

4.3 Variable Selection

Empirical studies differ on the choice of economic fundamentals that drive the exchange rate in the long run. For the purpose of this study, the variables that enter the cointegrating equation 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 in the 1970's, experiencing economic and political sanctions in the 1980's, the transition to 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 considers the following variables for inclusion in the long-run real effective exchange rate model[5]:

a) Real interest rate differential (+)

The real interest rate differential between South Africa and the country's 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 weighted average real 10-year bond yield of the country's major trading partners. Percentage change in CPI is used to deflate the nominal yields.

b) Net capital flows (+)

Net capital flows provide a reflection of the 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. Net capital flows is 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. The 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 (capital controls) after 1994, 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[6].

[5] Other variables that were considered include the gold price, money supply, commodity price index, government debt to GDP ratio, foreign exchange reserves and the nominal effective exchange rate.

[6] This variable 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.

c) Productivity differential (+)

This variable represents the Balassa-Samuelson effect which asserts 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, previous studies (e.g. Gan et.al, 2013; Wang et.al, 2007, MacDonald and 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 weighted average GDP per capita of the country's main trading partners less South Africa's real GDP per capita.

d) Terms of trade (+/-)

Terms of trade epitomize one of the channels for the transmission of global macroeconomic shocks to the local economy and the indicator is calculated as the relative price of a country's exports to the price of imports. The effect of terms of trade on the real effective exchange rate 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. Though theoretically important as a determinant of the real effective exchange rate 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 small open economy, it is highly exposed to terms of trade 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 gold price given the country's role as one of the largest producers of the yellow metal.

e) 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 liberalization. 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 an increase in external openness is associated with depreciation in the local currency for developing countries through a reduction in the domestic price of tradables.

f) 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 this depends on whether extra government funds are channelled towards tradable or non-tradable goods. A permanent expansion in government expenditure that increases demand for nontradables would induce an appreciation in the real effective exchange rate whilst government expenditure channelled towards imports of (e.g. capital equipment for infrastructure development) would cause the exchange rate to depreciate (Goldfajn and Valdes, 1999). In the aftermath of the 2007 global financial crisis, the South African government used countercyclical fiscal policy as one of the ways to stimulate economic growth and the impact of that on the exchange rate would be interesting to note.

V. Empirical Results

5.1 Unit Root tests

Table 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)
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)

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

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) 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 3 above[7]. 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 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

[7] The ADF test is also mainly criticised for exhibiting low power if the data generating process is stationary but with a root close to the non-stationary boundary (Brooks, 2008:330).

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[8]. Consequent on these unit root tests results, we proceed to test for the possible presence of a cointegration amongst the variables.

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 are 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 4 below presents a summary of the Johansen cointegration test result.

Table 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		
Hypothesized no. of CE(s)	**Eigenvalue**	**Trace statistic**	**0.05 Critical value**	**Prob.****	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob.****
None	0.311160	110.2618*	88.80380	0.0006	43.61137*	38.33101	0.0113
At most 1	0.212386	66.65041*	63.87610	0.0287	27.93343	32.11832	0.1491
At most 2	0.184354	38.71698	42.91525	0.1236	23.84162	25.82321	0.0893
At most 3	0.082152	14.87536	25.87211	0.5849	10.02966	19.38704	0.6157
At most 4	0.040570	4.845703	12.51798	0.6186	4.845703	12.51798	0.6186

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 4) endorse the existence of at least one cointegrating relationship amongst the variables confirming that over the long run the real effective exchange rate moves together with the terms of trade (including gold price), external openness, government expenditure and net capital flows[9]. The relative GDP per capita variable (Balassa-Samuelson indicator for relative productivity) coefficient is against *a priori* expectations with the opposite

[8] Appendix 1 shows a graphical presentation of the REER and variables that make up the cointegration model. 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 4 are for a model with a linear intercept and trend.

[9] The maximum eigenvalue test shows that one cointegration relationship exists amongst the variable 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 show 2 cointegrating equations.

sign and is hence excluded from the model[10]. The real interest rate differential variable was not statistically significant in the model and was also dropped.

The results from the vector error correction model estimates (see Appendix 2) have the correct signs and all appear within reasonable expectation. The adjustment factor of the cointegration equation (speed of adjustment) is negative (-36%) and statistically significant[11]. The adjustment coefficient indicates that 36% of disequilibrium is corrected in each quarter and the REER returns to its equilibrium level in about 3 quarters provided that there are no other shocks. Most importantly, a weak exogeneity test confirms that the real effective exchange rate is endogenous in the model. The results indicate a sufficiently large Chi-square statistic (9.1483) with a significant p-value. It is also worth noting the exchange rate is the most weakly endogenous variable in the system as 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 (Appendix 3) in the lag chosen. Such results allow us to estimate the cointegrating vectors by means of univariate methods.

Subsequent to confirmation of a cointegration relationship among the variables, a long run equilibrium exchange rate is estimated and its movements compared to the actual REER to ascertain the possible presence of misalignment in the rand. The Dynamic Ordinary Least Squares method (DOLS) is used to estimate the long-run cointegrating equation and the results are presented in table 5 below[12]. Hossfeld (2010) notes that the DOLS method improves robustness of the estimates as it caters for potential endogeneities among the variables.

Table 5: Long-run estimated equation results

	Results of BEER model (DOLS)					
Variable	**LTOT_INGOLD**	**LOPEN**	**K_FLOWS**	**LGOVT**	**CONSTANT**	**@TREND**
Coefficient	0.8157	-0.8533	0.5839	-0.3677	5.5924	-0.0016
	(7.3488)	(-15.5951)	(6.2626)	(-3.3135)	(25.8426)	(-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.

Table provides the estimated long-run real effective exchange rate 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

[10] MacDonald and Ricci (2004) do not find a strong effect of the Balassa-Samuelson effect in South Africa whilst Chowdhury (2012) finds a negative relationship between the exchange rate and productivity improvements in Australia.

[11] The speed of adjustment identified in this model is faster at 36% as compared to previous studies; de Jager (2012) found 28.50%; MacDonald and Ricci (2004) obtained 8%.

[12] Eviews 9 is used for the estimation of the DOLS model and the full results are presented in Appendix 4. The number of lead and lags in the model is 1 and is chosen to coincide with the lag selection criteria for the VAR cointegrating equation.

on 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 real effective exchange rate in the long run. The trend coefficient in the model is also statistically significant, confirming the presence of a trend in the cointegrating variables. A 1% increase in the country's terms of trade that includes the gold price will lead to an appreciation in the real effective exchange rate 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 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 of the estimated real effective exchange rate from the cointegrating relationship is used to define the equilibrium real effective exchange rate. Following on the previous works 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:

$$Mis_t = REER_t - REER_t(HP\_) \qquad [10]$$

Figure 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(b).

Figure 2: Actual versus Equilibrium REER & misalignment

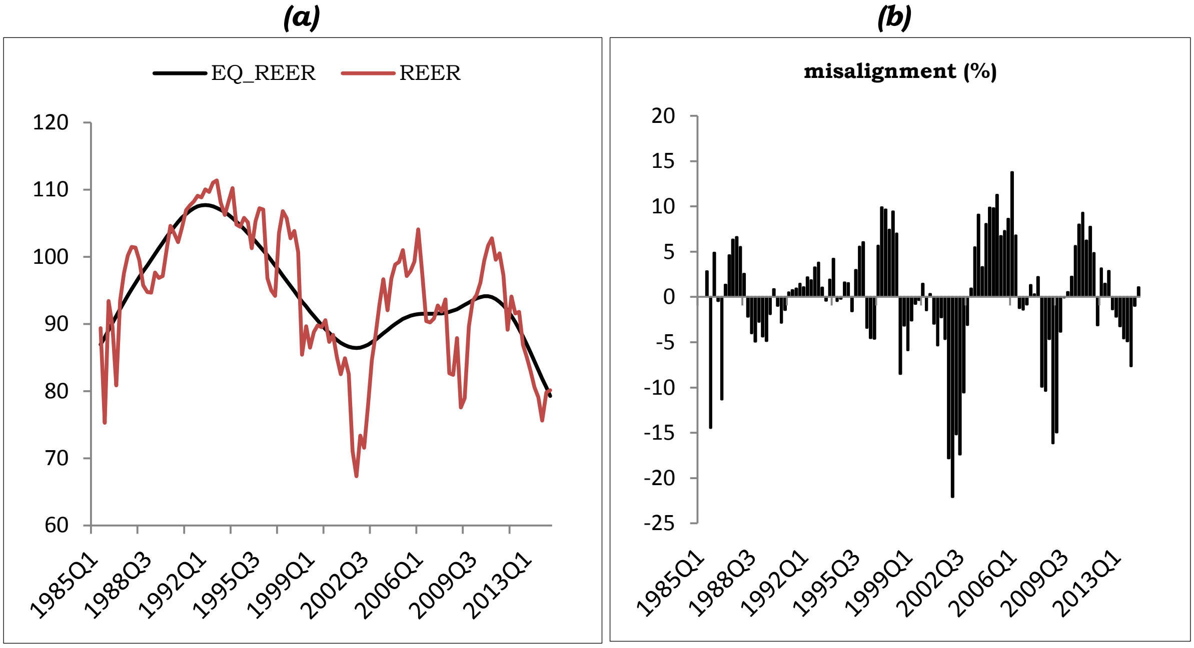


Figure 2 confirms that the exchange rate deviates from its equilibrium level over time with the historical misalignment pattern witnessed confirming similar observations from previous studies including de Jager (2012), Saayman (2010) and MacDonald and Ricci (2004). The study affirms an extreme undervaluation 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 the year 2006. Some undervaluation in the real effective exchange rate is also observed in 2014. The plot of the misalignment series (Figure 2(b) above) indicates the presence of abrupt changes or shifts in the direction 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 where 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 (summary statistics presented in Appendix 6) 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 some 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 (2010:123) note, a modelling method that identifies whether distinct regimes for misalignment (overvalued versus overvalued states) exist might provide a better fit for the data (misalignment series). The Markov regime switching model applied in the study endogenously determines the possible presence of appreciation and depreciation episodes that may be regarded as different deviations from the equilibrium exchange rate. Results from the MSM model are presented and discussed below.

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 (2) 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; REER appreciations and REER depreciations. Table 6 presents the results of the MSM and the key parameters of the model which confirms 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: state of overvaluation has a positive mean ($\mu_2=7.7067$) whilst the undervaluation episodes have a negative mean

(μ_1 = -2.2493). The results (Appendix 7) also confirm that the undervaluation regime has a higher volatility (5.608128) as compared to 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.

Table 6: MSM results[13]

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 state) 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 and Serletis, 2007). Notable in the MSM results is the higher probability of exchange rate being undervalued and the fact that undervaluation episodes seem to have on average longer durations (about 22 quarters versus 6) over the sample period (Appendix 7(b)). This is confirmed when we plot the estimates from the model of the probabilities of being in either of the two regimes over the full sample period.

Figures 4 and 5 plot the inferred probabilities (smoothed) from the MSM of being in regimes 1 and 2 and compares such episodes with the misalignment series estimated (solid lines) from the long run cointegration relationship. The MSM framework correctly identifies both undervaluation 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.

[13] The important parameters of the model (μ_1, μ_2, σ^2_1, σ^2_2, p_{11} and p_{22}) are reported. Eviews 9 was used to estimate the parameters reported.

Figure 4: Probability of being in regime 2 (REER overvalued)
P(S(t) = 2) Smoothed probabilities

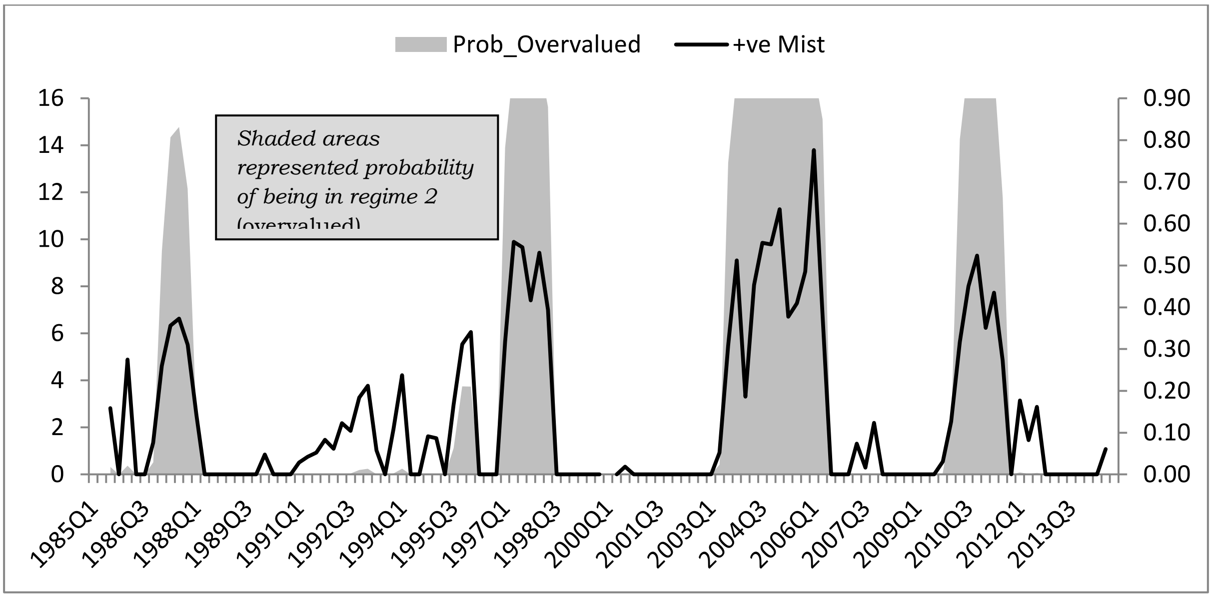
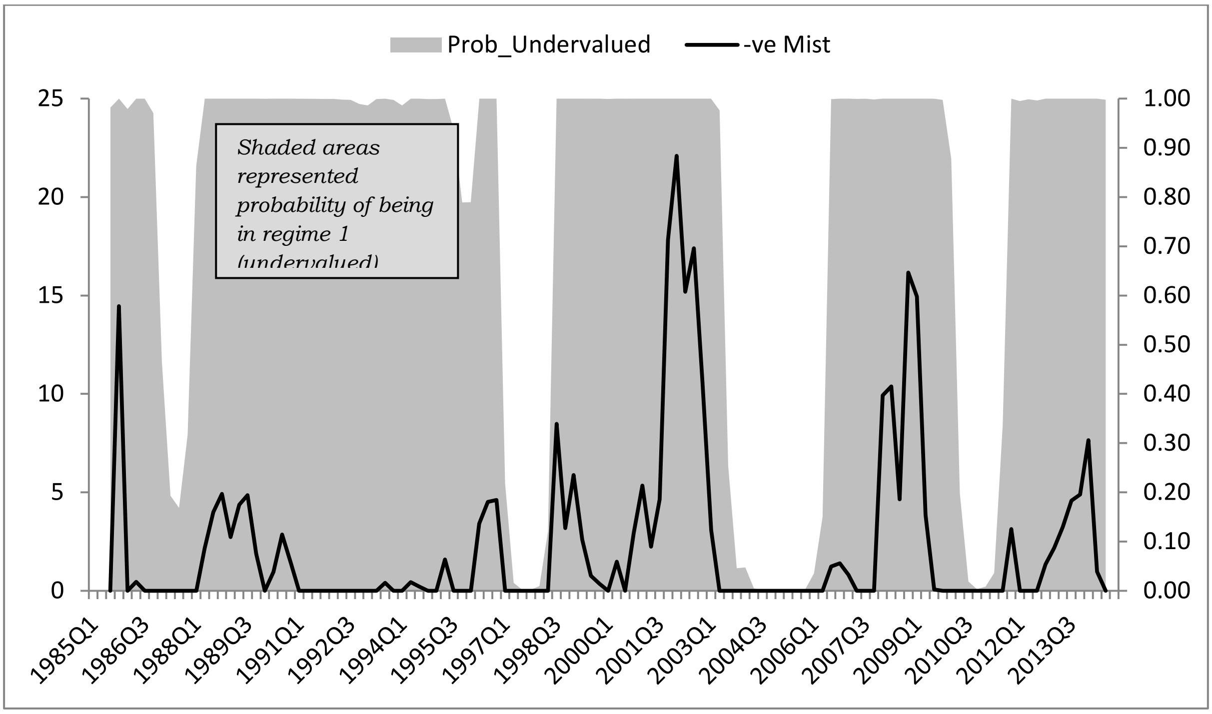


Figure 5: Probability of being in regime 1 (REER undervalued)
P(S(t) = 1) Smoothed Probabilities



VI. Concluding remarks and policy implications

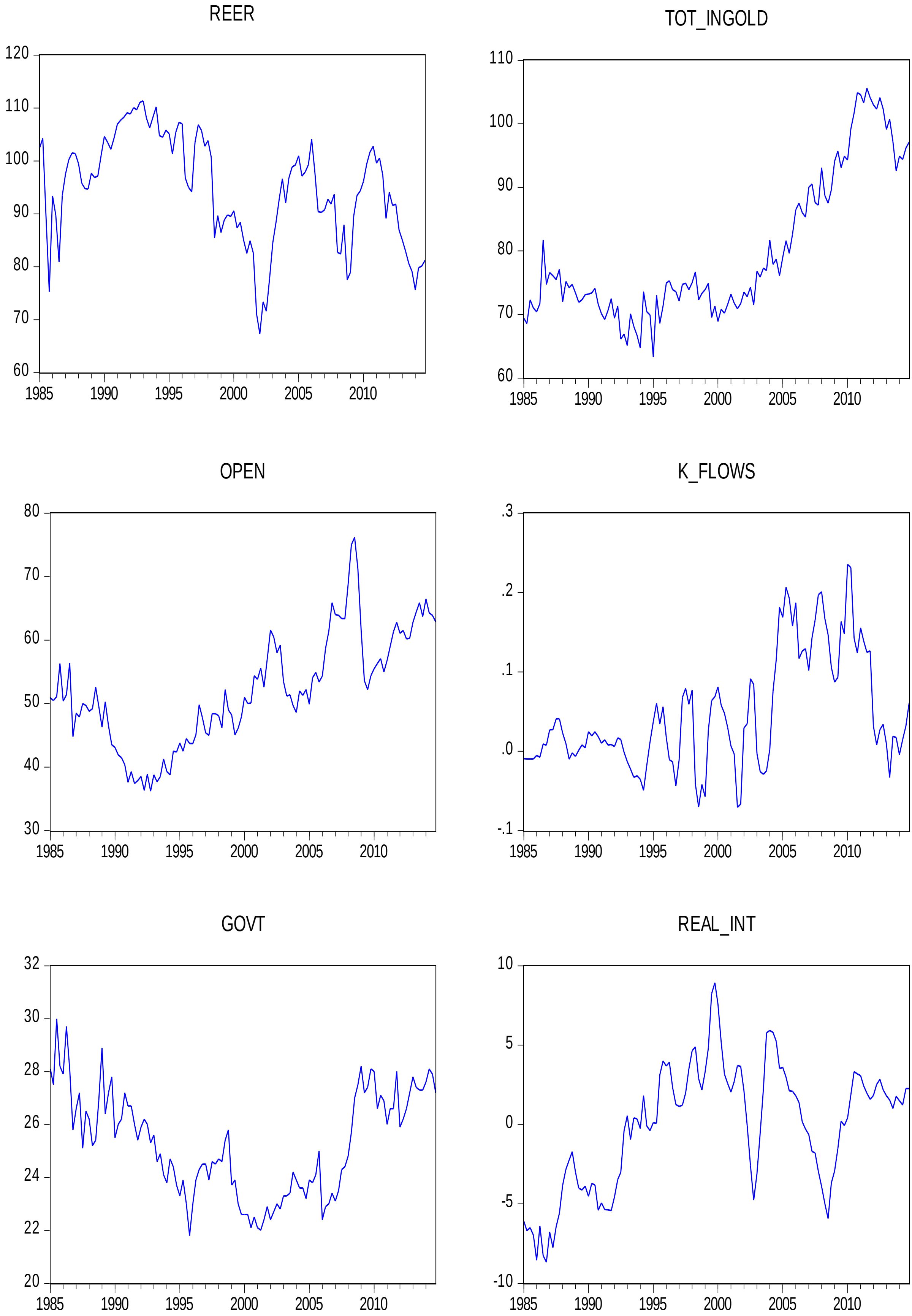
The real effective exchange rate plays a key role in the macroeconomic performance of the country and an analysis of its equilibrium level and the variables that determine this level is always essential. Applying the Behavioural Equilibrium Exchange Rate (BEER) approach, this study finds evidence that a long run equilibrium relationship exists between the rand's real effective exchange rate 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 Markov Switching Model correctly captures the misalignment over the sample period as distinct episodes of overvaluation 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 deferring 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 was undervalued between 2013 and 2014.

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 influence the results as well given the changing relative importance of economic indicators. An interesting observation from the study is that the exchange rate tended to be more undervalued than overvalued over the period studied with undervaluation episodes lasting longer than overvaluation periods. A closer look at the trade figures over the sample period indicates that South Africa's imports have been growing faster than exports (table 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 South African Reserve Bank. 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 has the country failed to take advantage of such misalignment episodes? From a policy perspective, this means policymakers have to look at other factors in an effort to boost export performance since there is no evidence that the exchange rate has been detrimental to exports. Rodrik (2008b) notes that South Africa's unsatisfactory growth and employment path realized since the democratic transition is a function of an under-performing 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, organized labour (unions) and the private sector to work together to find sustainable solutions to these challenges.

In terms of further research, it would be interesting to formally ascertain the impact of such a misalignment on economic indicators like growth, exports and the current account deficit. Since the study merely sought to measure if the exchange rate gets 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 Valdes (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 an area worth exploring.

Appendix 1: Variables for the long-run cointegration relationship



Appendix 2: VECM Results

Cointegrating Eq:	CointEq1
LREER(-1)	1.000000
LTOT_INGOLD(-1)	-1.019337 (0.15823) [-6.44225]
LOPEN(-1)	0.940687 (0.06713) [14.0127]
K_FLOWS(-1)	-0.587090 (0.13003) [-4.51498]
LGOVT(-1)	0.545331 (0.15403) [3.54048]
@TREND(85Q1)	0.001918 (0.00052) [3.71380]
C	-5.639256

Error Correction:	D(LREER)	D(LTOT_INGOLD)	D(LOPEN)	D(K_FLOWS)	D(LGOVT)
CointEq1	-0.361575 (0.08984) [-4.02457]	0.215023 (0.05965) [3.60462]	-0.160001 (0.09829) [-1.62791]	-0.010534 (0.06073) [-0.17347]	0.072097 (0.05934) [1.21489]
Weak exogeneity test					
Chi-square	9.148334	7.724346	1.722271	0.023490	1.028771
Probability	0.002489	0.005448	0.189401	0.878191	0.310448

Standard errors in () and t-statistics in [ ]

Appendix 3: VAR Serial Correlation Test

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Included observations: 118

Lags	LM-Stat	Prob
1	31.42557	0.1753
2	29.87075	0.2292

Probs from chi-square with 25 df.

APPENDIX 4: Dynamic Ordinary Least Squares (DOLS) Results

Dependent Variable: LREER
Method: Dynamic Least Squares (DOLS)
Cointegrating equation deterministics: C @TREND
Fixed leads and lags specification (lead=1, lag=1)
Long-run variance estimate (Bartlett kernel, Newey-West fixed bandwidth = 5.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LTOT_INGOLD	0.815704	0.183971	4.433870	0.0000
LOPEN	-0.853268	0.072531	-11.76411	0.0000
LGOVT	-0.367724	0.179597	-2.047497	0.0433
K_FLOWS	0.583910	0.145385	4.016303	0.0001
C	5.592386	0.408484	13.69060	0.0000
@TREND	-0.001630	0.000545	-2.989655	0.0035

R-squared	0.854813	Mean dependent var	4.543899
Adjusted R-squared	0.829882	S.D. dependent var	0.110653
S.E. of regression	0.045639	Sum squared resid	0.206212
Long-run variance	0.005107		

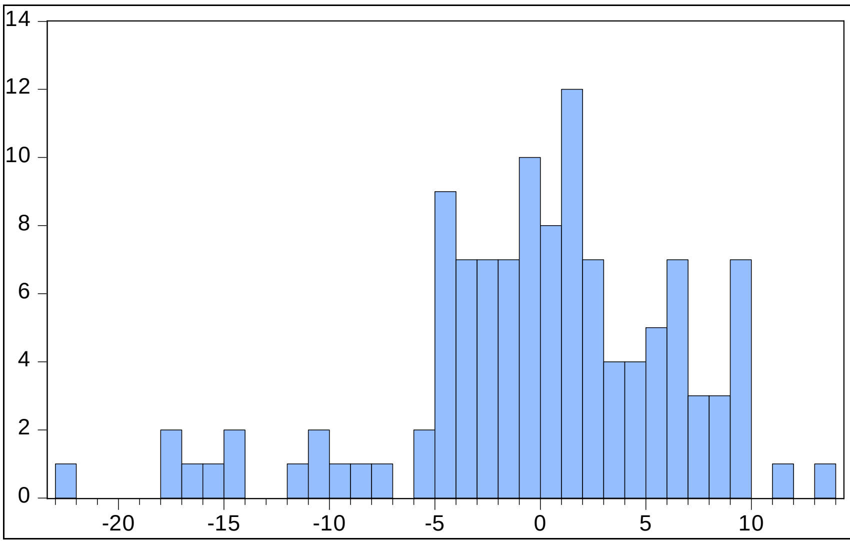
APPENDIX 5: VAR Lag Order Selection

VAR Lag Order Selection Criteria
Endogenous variables: LREER LTOT_INGOLD LOPEN K_FLOWS LGOVT

Lag	LogL	LR	FPE	AIC	SC	HQ
1	1072.645	NA	5.16e-15	-18.70795	-18.10114*	-18.46175*
2	1099.031	48.05994	5.05e-15*	-18.73269*	-17.51908	-18.24029
3	1115.885	29.19365	5.87e-15	-18.58723	-16.76681	-17.84863
4	1143.628	45.57766*	5.65e-15	-18.63621	-16.20898	-17.65141
5	1161.584	27.89650	6.54e-15	-18.51043	-15.47639	-17.27943
6	1170.148	12.53973	9.02e-15	-18.21693	-14.57608	-16.73972
7	1185.206	20.70546	1.12e-14	-18.03940	-13.79175	-16.31599
8	1206.808	27.77365	1.26e-14	-17.97872	-13.12425	-16.00911

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Appendix 6: Summary Statistics for Misalignment Series



Series: MIS_T
Sample 1985Q1 2014Q4
Observations 117

Mean	-0.016313
Median	0.546589
Maximum	13.79928
Minimum	-22.09738
Std. Dev.	6.572756
Skewness	-0.802680
Kurtosis	4.036484
Jarque-Bera	17.80097
Probability	0.000136

APPENDIX 7 (a): MSM Results for Misalignment Series

Dependent Variable: MIS_T
Method: Markov Switching Regression (BFGS / Marquardt steps)
Sample (adjusted): 1985Q3 2014Q3
Included observations: 117 after adjustments
Number of states: 2
Initial probabilities obtained from ergodic solution
Standard errors & covariance computed using observed Hessian
Random search: 25 starting values with 10 iterations using 1 standard deviation (rng=kn, seed=1870984810)
Convergence achieved after 6 iterations

Variable	Coefficient	Std. Error	z-Statistic	Prob.
		Regime 1		
C	-2.249389	0.655507	-3.431524	0.0006
LOG(SIGMA[14])	1.724216	0.078476	21.97126	0.0000
		Regime 2		
C	7.706776	0.551831	13.96582	0.0000
LOG(SIGMA)	0.833826	0.162565	5.129196	0.0000
		Transition Matrix Parameters		
P11-C	3.054550	0.564622	5.409899	0.0000
P21-C	-1.601351	0.550639	-2.908169	0.0036

Mean dependent var	-0.016313	S.D. dependent var	6.572756
S.E. of regression	5.826200	Sum squared resid	3835.740
Durbin-Watson stat	0.929952	Log likelihood	-365.4441
Akaike info criterion	6.349472	Schwarz criterion	6.491122
Hannan-Quinn criter.	6.406980		

[14] The variances from Eviews 9 are reported in log form. Anti-logs are taken and reported in table 6.

APPENDIX 7 (b): MSM transition probabilities

Equation: MSM_01
Transition summary: Constant Markov transition probabilities and expected durations

Sample (adjusted): 1985Q3 2014Q3
Included observations: 117 after adjustments

Constant transition probabilities:
P(i, k) = P(s(t) = k | s(t-1) = i)
(row = i / column = j)

	1	2
1	0.954979	0.045021
2	0.167793	0.832207

Constant expected durations:

	1	2
	22.21163	5.959727

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