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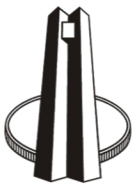
Modelling South Africa's equilibrium real effective exchange rate: A VECM approach

Shaun de Jager



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Research Department

Modelling South Africa's equilibrium real effective exchange rate: A VECM approach

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Abstract

It is not the South African Reserve Bank's (SARB) policy to intervene in the financial markets, which essentially means that the external value of the rand is considered to float freely. As a result, the level of the currency is determined by the supply/demand fundamentals governing price behaviour in the financial markets. This paper investigates the various factors that may have an impact on the level of the exchange rate, and estimates a suitable model to measure the level of the equilibrium real effective exchange rate. The results from the model suggest that the equilibrium level may be determined by the effects of key economic fundamentals, including an interest rate differential, a suitable productivity measure, commodity prices, the fiscal balance and capital flows. Deviations of the actual level from this estimated equilibrium level can then be used to indicate whether the prevailing level of the exchange rate is either under or over-valued. On the basis of these fundamentals, it was found that the actual level of the real effective exchange rate was close to its equilibrium in the last quarter of 2011, but that it is currently less than five per cent overvalued (appreciated) relative to its equilibrium in the first quarter of 2012. It should be noted that this model serves only to indicate a possible equilibrium level based on the given economic fundamentals. Although the study provides a clear indication whether the level of the exchange rate is inconsistent with a set of given fundamentals, the estimated equilibrium in this study should nevertheless remain to be considered as an unobservable.

JEL classification: F31, F41

Key words: equilibrium real effective exchange rate, VECM, econometric model, economic fundamentals.

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1. Introduction

Greater policy effort to avoid currency overvaluation in South Africa "is warranted"…
Organisation for Economic Cooperation and Development (OECD,2010)

The functions of the South African Reserve Bank (Bank) have changed, and expanded over time. However, the formulation and implementation of monetary policy remains the essence of its activities,- especially the Bank's commitment to ensuring financial market stability and low inflation[2]. Problems from the global financial crises have highlighted the challenges faced by central banks to achieve domestic price stability and ensure that their financial markets are functioning adequately. In addition, there is intense debate in South Africa with regard to the central bank's intervention in the financial markets, as many still perceive this to be essential if the Bank wants to increase our international competitiveness and pace of domestic economic growth. South Africa's policy makers have often been called upon to defend their exchange rate policy actions, i.e. despite the Bank's repeated assertion that the exchange rate is predominantly derived from the interaction of market forces[3].

A suitable measure of the country's international competitive position is still regarded as a key variable when evaluating the authorities' success to promote long-run sustainable economic growth. Unfortunately, the concept of international competitiveness is a multidimensional phenomenon that is rather difficult to define or capture in a single indicator. As a result, the real exchange rate (i.e. the inflation differential adjusted nominal exchange rate) is often used to reflect the countries' relative competitive position in international trade (Walters & de Beer, 1999: 54)

Even within a country, the deviation of the actual real effective exchange rate from some fundamental equilibrium level still provides valuable information on the competitiveness of the currency. However, equilibrium concepts remain unobservable and despite the many efforts, there is no single (perfect) measure of the equilibrium or the extent of an over or undervaluation of a currency. Aaron, Elbadawi & Kahn (1997) suggest that the appropriate level of the real exchange rate is the level consistent with "sustainable" long-term capital flows, and a level that is conducive to generating a more open export-oriented economy. Another notion stems from the erratic behaviour of exchange rates, and the fact that short term fluctuations generally converge back to some equilibrium value or level over the long term. The long-run equilibrium hence refers to the level of the exchange rate that prevails once the short-term '*noise*'

[2] In February 2000, an inflation target set by the government was introduced as the anchor of monetary policy. This entrusted a single ultimate monetary policy objective to the Bank for ensuring price stability (Mboweni, 2003).

[3] The SARB is committed to a flexible exchange rate regime. The Bank's policy continues to be that the exchange rate remains market-determined, and therefore the policy is to accumulate reserves and not to defend or achieve a particular level for the exchange rate. (Mminele, 2011).

components are removed (Brook & Hargreaves, 2000: 2). Spatafora and Stavrev (2003) note that an accurate analysis of the real exchange rate is even more critical for resource dependent economies where they often experience large shocks to their terms of trade and relative productivity differentials. As a result, their currency values may experience extreme volatility, and the equilibrium level should therefore be monitored constantly.

This paper focuses on a few fundamental explanatory variables perceived to influence the level the equilibrium real effective exchange rate. It accordingly draws on previous efforts to estimate an equilibrium path of the South African real effective exchange rate by means of a Vector Error Correction Model (VECM) technique and strives to quantify the extent of the misalignment of the effective exchange rate from its long-run equilibrium value. Further in depth analysis of the equilibrium helps to determine whether the equilibrium level has in fact changed, or merely reflects a temporary deviation from its long-run equilibrium level (which is most often the case).

2. Previous studies on the compilation of an exchange rate equilibrium

Not surprisingly, there have been numerous studies on exchange rate fundamentals and associated currency misalignment. MacDonald (2000) provides a critical overview of the various methods to construct an equilibrium exchange rate. Here he notes that the well-known purchasing power parity (PPP) condition (i.e. inflation differentials) is not a suitable means to derive an equilibrium real effective exchange rate[4]. Mac Donald argues that the real explanatory determinants of the exchange rate should be explicitly modelled by means of a Behavioural Equilibrium Exchange Rate (BEER). Clark and MacDonald (1999) use VECM technology to estimate BEER's for the real effective exchange rates of the United States of America dollar, Japanese Yen and German Mark for the period from 1960 to 1996 (i.e. based on annual data). Here they found that the long run component of the equilibrium exchange rate can be modelled as a function of net foreign assets, productivity differentials and terms of trade effects.

The Fundamental Equilibrium Exchange Rate (FEER) approach advocated by Williamson (1994) suggests that the FEER is calibrated at a level that is consistent with both an internal and external balance. Internal balance in the FEER is obtained when a country is operating at a level of output consistent with full employment and low inflation. External balance in the FEER is characterised by a sustainable current account position, i.e. as reflected by the underlying and desired net capital flows (Maesofernandez, et al, 2001: 8).

[4] Mac Donald states that the PPP methodolgy ignores real determinants of the exchange rate such as relative activity levels and net foreign asset (capital) flows (MacDonald, 2000: 7).

Driver and Westaway (2001) decompose a BEER into “current and cyclical equilibrium exchange rates", i.e. where the “cyclical” variables wash out or erode over time. This transition helps to identify the permanent and transitory components. Gonzalo and Granger (1995) use this transition to define the so-called Permanent Equilibrium Exchange Rate (PEER)[5]. Although their analysis illustrates that the basic trends of the PEER and BEER were found to be similar, the PEER was somewhat smoother, as it was purged of any temporary or transitory effects.

Maesofernandez (2001) focuses on the computation of a BEER/PEER for the euro area based on a reduced form specification. Here they link the effective exchange rate of the euro to a broad set of economic fundamentals. They then apply standard cointegration techniques to decompose the exchange rate into its permanent and transitory components. They conclude that the main determinants of the euro’s effective exchange rate includes both a productivity and real interest rate differential, government expenditures, net foreign assets and the terms of trade using the real price of oil as a proxy (Maesofernandez, et al, 2001: 34).

MacDonald and Ricci (2003) employ Johansen’s (1995) maximum likelihood estimation methodology in a standard VECM specification (MacDonald and Ricci, 2003: 10). They estimate a quarterly equilibrium real effective exchange rate for South Africa from 1970 to the first quarter of 2002. Their long-run equilibrium real exchange rate includes commodity price movements, productivity and real interest rate differentials (relative to trading partner countries), a measure of openness, the fiscal balance and the net foreign asset position. A further interesting result concluded from this study was that in the absence of any further shocks, it would take between 2 to 2½ years for half the gap (or temporary deviation in the exchange rate) to revert back to its equilibrium level.

Other studies such as Aron, Elbadawi and Kahn (1997), make use of a single equation estimation technique to derive the long-run equilibrium relationship between 1970 and 1995. Their specified model not only provides for a flexible dynamic adjustment of the real exchange rate towards its equilibrium real exchange rate, but also provides for short to medium-run macroeconomic and exchange rate policy effects on the level of the real exchange rate (Aaron, et al, 1997: 23). They suggest that the key explanatory variables of the model would need to include the terms of trade, the price of gold, tariffs, capital flows, official reserves and government consumption expenditure. According to their calculations, they found that it would take roughly 3½ quarters (0,86 of a year) to eliminate 50 per cent of the shock. Although their estimation period and technique is different to the VECM methodology suggested by MacDonald and Ricci, the estimated period of time for the exchange rate to revert back to its equilibrium level was found to be considerably quicker.

[5] Gonzalo and Granger (1995) incorporate some shock dynamics into the permanent component. This, in essence, allows a change in the transitory component to have a lasting impact on the change in the permanent component – which in turn, then influences the equilibrium level.

Saayman (2010) makes use of panel data and the behavioural equilibrium approach (BEER). Her results suggest that the fundamental value of the exchange rate was driven by economic growth, the openness of the economy, its foreign reserves, the real price of gold and capital expenditure. She furthermore concludes that although the exchange rate fluctuates considerably around its equilibrium level, there were no sustained periods of an over- or undervaluation of the exchange rate.

In a similar fashion to the papers of MacDonald (2002) and MacDonald & Ricci (2003), this research study also makes use of the VECM estimation technique. The associated Johansen methodology has a number of important advantages, including the early detection of spurious regressions when using non-stationary variables, i.e. unless at least one cointegration vector is present (Harris, 1995: 76). The VECM technique essentially separates the long-run component (cointegrating vector) from the short-run VAR model in first differences, and it is this vector that is used to generate the equilibrium level of the real effective exchange rate.

3. Variables used in the compilation of the equilibrium exchange rate

The explanatory variables of this study are classified into five broad categories. These include the financial sector (real interest rates), commodity prices and terms of trade, the fiscal balance sector, the real sector (productivity measures) and the international sector (trade openness and capital flows). A brief description of the codes and the source of the variables used in the model are provided in Table 1a of the appendix.

3.1 The financial sector

The relative interest rate differential between domestic and foreign real interest rates (*rirrus*) reflects the uncovered interest rate parity condition (UIP), which states that the domestic interest rate must be higher than the foreign interest rate by an amount equal to the expected depreciation of the domestic currency (Copeland, 1989). According to economic theory the interest rate differential should tend to equalise across countries in the long run, however, the empirical evidence suggests that this is not necessarily the case. On the assumption that the uncovered interest rate parity holds and that all other factors (such as a risk premium etc.) are constant, an increase in the domestic interest rate relative to other countries would tend to attract foreign capital and cause an appreciation of the domestic currency (i.e. the carry trade). In this study the SA prime rate and PPI inflation is used to determine the real domestic interest rate, while the USA prime rate and the foreign wholesale price inflation prevailing in our major trading partner countries has been used to generate the foreign real interest rate.

3.2 Commodity prices and the terms of trade

South Africa is regarded as a commodity exporter, and the rising trend in international commodity prices generally causes the exchange rate to appreciate as foreign investors become more interested in commodity market equities and bonds. As commodity prices start to increase, wage rates in these export sectors increase which eventually leads to higher prices. At the same time, rising commodity prices induces a positive wealth effect, which would most probably raise the level of domestic demand and inflation. The real effective exchange rate of the rand would then start to appreciate as domestic inflation starts to increase (i.e. relative to that of the trading-partner countries). MacDonald and Ricci (2003) capture these effects with a terms of trade variable, where the numerator reflects the price of all exports (not just commodity-based exports), and the denominator, the price of country-specific imports. However, they also add that few studies find a significant effect from the terms of trade[6], and that many researchers find a strong cointegrated relationship between commodity prices and the real exchange rate,- especially commodity exporters (MacDonald & Ricci, 2003: 4). This study makes use of a relative commodity price variable, proxied by South Africa's dollar denominated export commodity price index relative to the imported oil price in dollars. The intuition is for the currency to become more appreciated as the commodity export price rises.

3.3 The fiscal sector

The fiscal balance via the government deficit to GDP ratio (*gvdef5_gdp)* appears to have a somewhat ambiguous effect on the level of the real effective exchange rate. An improved fiscal position (caused by either a reduction in government expenditure or an increase in government revenues) essentially leads to more funds flowing to the public sector. The reallocation of resources from the private sector would cause a decline in domestic demand, and the ensuing reduced demand pull pressures will generally lead to lower domestic prices (i.e. declining rates of inflation). It is largely this price effect that induces a depreciation of the real effective exchange rate. In addition, secondary effects may be related to the fact that as domestic growth prospects decline, scarce foreign capital tends to flow out of the country in search of higher yields from more profitable destinations.

3.4 The real sector

Real exchange rate effects from the manufacturing productivity differential between South Africa and one of its major trading partner countries (USA) is denoted by the

[6] Aaron et al. (1997) make use of the terms of trade. However, they also found that when gold is included in the terms of trade, gold price movements outweighed the non-gold terms of trade causing an upward bias of the overall terms of trade (Aaron, Elbadawi and Kahn, 1997: 13).

variable (*proddiff*) in the model. This productivity component makes provision for the so-called Balassa-Samuelson effect which states that if a country experiences an increase in the productivity of its tradable sector (i.e. relative to that of its trading partner countries), its real effective exchange rate would start to appreciate (MacDonald and Ricci, 2003: 4). To illustrate, Balassa and Samuelson identified that productivity growth differentials between the sectors producing tradable and non-tradable goods can be used to introduce systematic bias to the relationship between relative prices and real exchange rates. Historically, productivity growth in the traded goods sector has been faster than in the non-traded goods sector, and according to the law of one price, the prices of tradables tend to equalise across countries, while the prices of non-tradables do not. This implies that higher productivity in the tradable goods sector will normally bid up or raise wages in that sector, suggesting that if there was perfect mobility of labour; the wages in the entire economy would rise. Producers of non-tradables will be able to pay the higher wages only if the relative price of non-tradables also rises (Mihaljek & Klau, 2003). This effect will in general lead to an increase in the overall price level in the economy and consequently cause an appreciation of the real effective exchange rate.

3.5 The international sector

The international sector can be represented by various variables such as the current account of the balance of payments, the change in net gold and other foreign exchange reserves, and foreign capital flows. However, the variable used in this study reflects the net foreign capital inflow to GDP ratio (*capmv5_gdp)*. Foreign investors require a return on their investment and if South African bonds and equities offer them a reasonable yield (i.e. relative to another country), then they may feel obliged to invest in the domestic economy. The sign of this variable would have to be positive since a capital inflow generally signifies that the value of the domestic currency would appreciate.

Trade liberalisation, the easing of trade restrictions and a more open trade policy regime are also likely to be associated with a more depreciated value of the real effective exchange rate. Trade restrictions would normally increase the price of goods, thereby raising the overall price level (or inflation), and as domestic rates of inflation rise relative to trading partner countries, so too would the real exchange rate start to appreciate (MacDonald and Ricci, 2003). The measure of openness (*openn*) used in this study reflects the widely used ratio of the sum of nominal exports and imports of goods and services to nominal gross domestic product.

This study hence makes use of six independent explanatory variables to define the equilibrium real effective exchange rate. These variables represent a diverse variety of effects, i.e. ranging from interest rate and relative productivity differentials to the fiscal balance and other balance of payment issues. The determinants of the equilibrium

exchange rate are graphically depicted in Figure 2a of the Appendix at the back of this study.

4. Results and estimation of the equilibrium exchange rate

The first step is to determine whether the variables in the VECM model are valid, and that there is evidence of a cointegrated relationship. It is often assumed that the data in the multivariate set are non-stationary, and that a stationary cointegrated relationship(s) would therefore need to be found to avoid the problem associated with spurious regression. The order of integration of each variable that enters the multivariate model therefore becomes important, and the following table shows the Augmented Dickey-Fuller (ADF), Elliott-Rothenberg-Stock (DF-GLS) and Kwiatkowski Phillips-Schmidt-Shin (KPSS) tests that have been performed to test for variable stationarity in level terms.

Table 1 : Integration tests (levels) over sample period 1982q1 to 2011q2

Variable	I(0)			
	ADF(AIC)	ADF(SIC)	DF-GLS	KPSS
EXREALD	-2.790*	-2.790*	-1.554	0.585
RIRRUS	-3.063*	-3.382*	-0.900	0.543
PRODDIFF	-2.516	-2.373	0.704	1.236
FORCMD/(OILPDD*100)	-2.119	-2.906*	-1.894	0.605
OPENN	-0.990	-0.990	-0.702	1.119
GVDEF5_GDP	-2.223	-2.223	-0.929	0.286*
CAPMV5_GDP	-2.678	-2.678	-2.465*	0.787

Note: ADF(AIC) : number of lags determined by the Akaike information criteria
ADF(SIC) : number of lags determined by the Schwartz information criteria
DF-GLS : Elliott-Rothenberg-Stock (DF-GLS) test statistic
KSS : Kwiatkowski Phillips-Schmidt-Shin (KPSS) test statistic
* denotes significance at the 5 per cent level
** denotes significance at the 1 per cent level

The results shown in Table 1 suggest that all variables, with the possible exception of the real interest rate differential *(rirrus)*, and to a lesser extent the real effective exchange rate *(exreald)* and the capital flows *(capmv5_gdp)* are non-stationary in their level terms. In addition, despite the results not being shown here in Table 1, all the standard order of integration tests confirm first difference stationarity "I(1)" at the 1 per cent level. The results from this group of order of integration tests furthermore confirms the strong likelihood that at least one or more cointegrating vectors will be able to be extracted from the seven variable data set.

Since this study is primarily concerned with the long-run properties of the model to derive the equilibrium exchange rate, attention is now focused on the existence of cointegration between the various variables of the model. The process first determines whether there are cointegrating vectors, and secondly how many of theses vectors

exist. The results obtained from applying the Johansen reduced rank regression approach to the variables of the model are shown in the following two tables.

Table 2 shows a collection of the five different assumptions that can be made with regard to the data (although in practice, Cases 1 and 5 are rarely used). The results suggest strong evidence of only one cointegrating vector for Case's 2 and 3, while there may be more for Case's 4 and 5. Since all trends are perceived to be linear and stochastic in nature (without a trend), it was assumed to only rely on the results of case 3 which incidentally also allows for an intercept.

Table 2 : Summary of assumptions of the cointegration test

Date: 11/09/11 Time: 13:42
Sample: 1980Q1 2011Q2
Included observations: 117
Series: LREXR RIRRUS @MOVAV(PRODDIFF(-1),2) @MOVAV(LOG(FORCMD/(OILPDD*100)),4) @MOVAV(OPENN,1) @MOVAV(GVDEF5_GDP(-1),4) @MOVAV(CAPMV5_GDP,2)
Lags interval: 1 to 4

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	*Case 1:* None	*Case 2:* None	*Case 3:* Linear	*Case 4:* Linear	*Case 5:* Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	0	1	1	2	2
Max-Eig	0	1	1	2	2

*Critical values based on MacKinnon-Haug-Michelis (1999)

The evidence from the Johansen procedure suggests there is only one cointegrating vector in Case 3 of the VECM, and therefore only one valid relationship for the exchange rate *(lrexr)* was imposed. The estimated coefficients (i.e. from the so-called β vector), can now be used to compute the level of the equilibrium real effective exchange rate. Another important feature of the methodology is that an estimate of the speed at which the real exchange rate converges to its equilibrium level can be derived from the adjustment factor.

The following results in Table 3 show the estimated parameters of the long-run relationship as defined by the β vector. These estimated parameters can also be used to derive the long-run elasticity of each explanatory variable in the VECM, for example, a one percent increase in the real interest rate differential *(rirrus)* would induce a 0,8 per cent appreciation of the real effective exchange rate. The results of the VECM model furthermore show that all the estimated coefficients are plausible and more importantly have the correct sign.

Table 3 : The VECM estimates of the long-run real effective exchange rate

Vector Error Correction Estimates
Date: 11/08/11 Time: 11:42
Sample (adjusted): 1982Q2 2012Q1
Included observations: 120 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LREXR(-1)	1.000000
RIRRUS(-1)	-0.007989 (0.00217) [-3.67677]
@MOVAV(PRODDIFF(-2),2)	-1.237069 (0.26813) [-4.61365]
@MOVAV(LOG(FORCMD(-1)/(OILPDD(-1)*100)),4)	-0.114355 (0.05536) [-2.06573]
@MOVAV(OPENN(-1),1)	0.554455 (0.36801) [1.50662]
@MOVAV(GVDEF5_GDP(-2),4)	1.507428 (0.81323) [1.85363]
@MOVAV(CAPMV5_GDP(-1),2)	-4.151882 (0.48092) [-8.63320]
C	-4.542367
Error Correction:	**D(LREXR)**
CointEq1	-0.286284 (0.10209) [-2.80421]

This study is primarily interested in the estimation of a unique long run cointegrated relationship for the real effective exchange rate, and not much emphasis is placed on the short run dynamics of the equation. As a result, the VAR component of the VECM is left unconstrained to make use of the full data set, and restrictions would need to be

imposed (both long-run and short-run) if an impulse response analysis of the short run dynamics was to be considered.

It also important to note the adjustment factor of the cointegrating equation. In essence, once a gap between the real exchange rate and its estimated equilibrium level develops (for whatever reason), the real exchange rate will tend to converge back to its equilibrium level over the longer term. Depending on the extent of the misalignment, the adjustment factor ensures that the real exchange rate moves progressively towards the defined equilibrium level. The results of the model show that the speed of the adjustment term is statistically significant, has a negative sign and has a value of slightly less than 0.30. This result suggests that, on average, roughly 28½ per cent of the gap will be eliminated in every quarter, implying that in the absence of any further shocks, more than half the gap would be closed within the space of two quarters.

This speed of adjustment is somewhat faster than in the study by MacDonald and Ricci (2003). Here they found that the adjustment factor was roughly 8 per cent, and that about half the gap would only be closed within the period of eight-to-ten quarters. However, they do also mention that large deviations such as those experienced in 2001 and 2002 may take less time to absorb. The adjustment factor in this study is also larger than the study by Aaron, Elbadawi and Kahn (1997) who report that it would take slightly less than three-and-a-half quarters to eliminate fifty per cent of the shock.

5. The derived equilibrium level of the real exchange rate of the rand

Some of the explanatory variables exhibit a great deal of "noise" or volatility, and it is likely that the estimated equilibrium real exchange rate would illustrate the same characteristic. Smoothing techniques such as the Hodrick-Prescott[7] (HP) filter have been applied to the equilibrium to neutralise the volatile fluctuations. The choice of the degree of smoothing is arbitrary, and since the data are quarterly, a smoothing factor of 1600 has been selected. A larger (smaller) factor would generate a smoother (less smooth) equilibrium level. The HP filter has the further limitation that it tends to perform poorly at both ends of the time series, and caution should be exercised when an analysis of these end periods is undertaken[8].

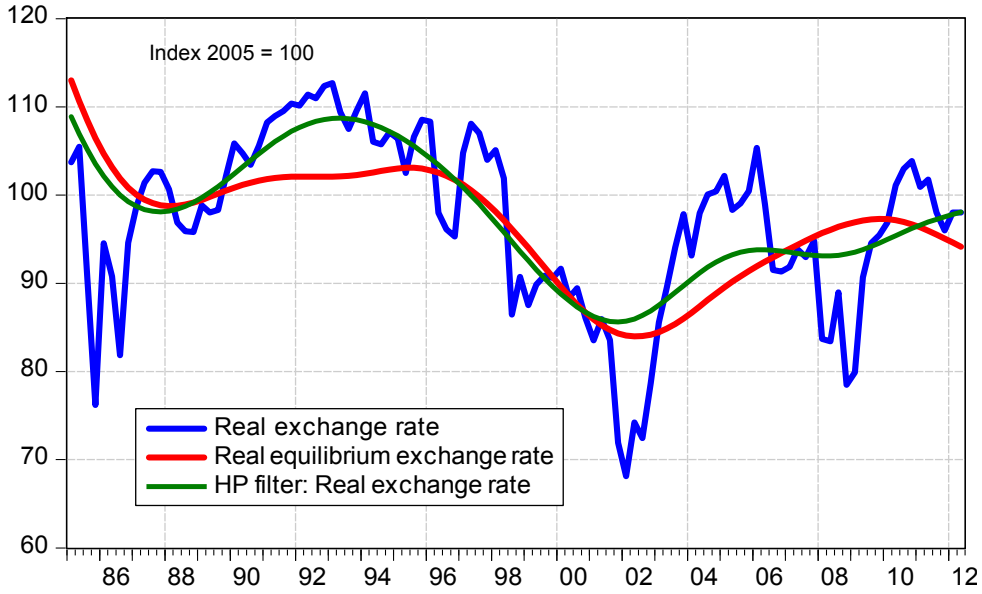
As this problem is a concern, it was decided to also make use of the HP filter on the actual real effective exchange rate as well, i.e. so as to identify how this trend evolves

[7] This statistical smoothing method is used to eliminate short-run cyclical movements to estimate the long-term trend component of a series. Technically, the Hodrick-Prescott (HP) filter is a two-sided linear filter that computes the smoothed series of the variable by minimising the variance around the specific variable (Eviews, 2001).

[8] The Hodrick-Prescott (HP) filter has been criticized due to its end-point bias, i.e. in that the last point of the series has an exaggerated impact on the trend at the end of the series. This is not that serious if one is only interested in the properties of the full cycle, but if the trend is important, then the last point is likely to be the one which is particularly interesting (Bruchez, 2003: 3).

over time in relation to the smoothed equilibrium level. Figure 1 shows the raw data of the real effective exchange rate as well as the close relationship of the smoothed HP filter to the derived equilibrium real effective exchange rate over the longer term. It is also interesting to note that the equilibrium level seems to suggest a gradual depreciation from the early quarters of 2010, which seems to be in direct contrast to the appreciating trend of the filtered actual over the same period to 2012[9].

Figure 1 : The real effective exchange rate and its equilibrium level



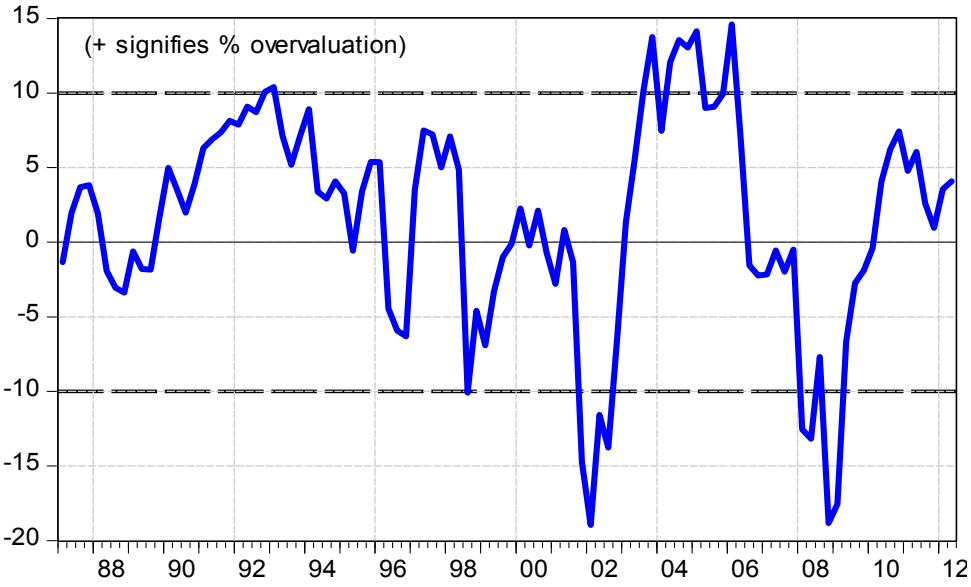
Bearing in mind the end-point limitation, the fundamentals of the model point towards a severe undervaluation of the currency during 2001 and 2002, but that this was viewed to be temporary in nature, and the correction occurred fairly quickly during the subsequent years to 2003. This was similar to the misalignment in the 2008-2009 period in which the currency was also severely undervalued, but also returned to its equilibrium relatively quickly. On both occasions, the exchange rate was undervalued, but then returned back to equilibrium within a period of eight quarters. In fact, the extent of the real effective exchange rate appreciation during 2009 and 2010 has been such that it now still indicates a substantial overvaluation in the first half of 2011.

The following graph illustrates the degree (or percentage) of imbalance of the real effective exchange rate from its equilibrium level, i.e. as defined by the deviation of the actual from the smoothed trend of the equilibrium's HP filter. Figure 2 furthermore suggests that there was no fundamental reason for the real effective exchange to depreciate by roughly 20 per cent from its equilibrium level during the 2001 and 2002

[9] Assumed values for all the explanatory variables have been incorporated in the model in order to generate an estimate of the real equilibrium to the second quarter of 2012. Although not a solution, this also helps to ease some of the problems associated with the end point bias.

period. This rapid rate of depreciation was most probably the result of other external factors that are difficult to take into consideration, i.e. these would include speculative attacks on the currency, etc. Although the fundamentals did suggest a further depreciation, this was still far less than the actual pace of depreciation that took place towards the end of 2001. The period from 2003 to 2006 was characterised by a fairly rapid appreciation of the currency which was also supported by the trend of the equilibrium. In fact, the level of the actual real currency appreciated in excess of its fundamentals by more than 10 per cent over much of this period. It is also interesting to note that the fundamentals were still suggesting a gradual appreciation of the exchange rate during the global financial crises period from the latter half of 2007 onwards. As a result, this may have aggravated the extent of the undervaluation of the currency towards the end of 2008 in particular. Finally, the real effective exchange rate appears to be roughly 5 per cent overvalued during 2010 and 2011, and the fact that the equilibrium gradually depreciates throughout 2011 suggests the value of the currency may remain overvalued over the remainder of 2011 (albeit at a declining trend).

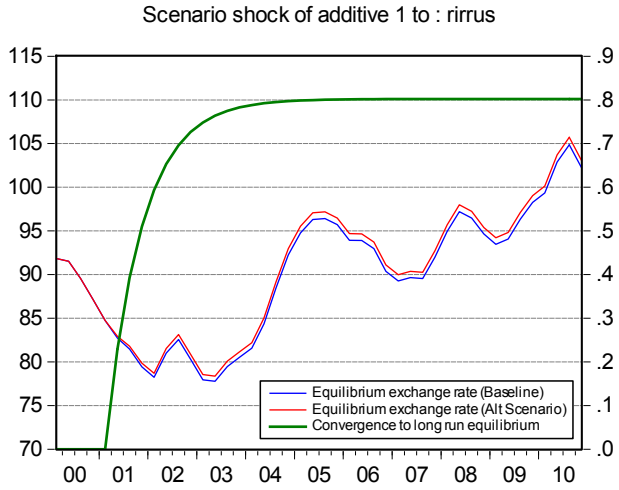
Figure 2 : The percentage difference of the actual real exchange rate from its equilibrium level



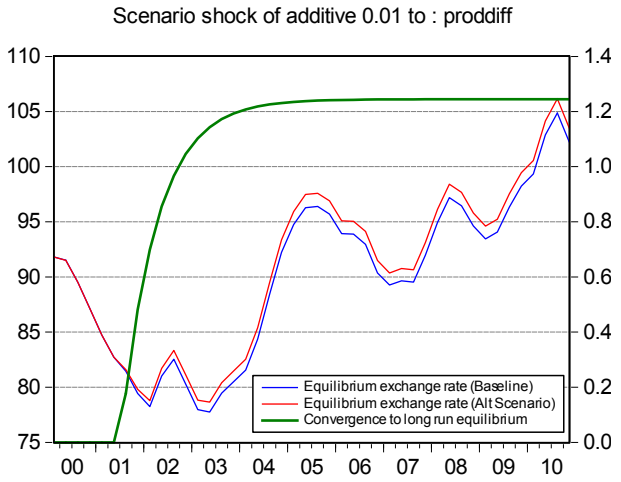
It is worth noting here that the actual real effective exchange rate is likely to differ from the equilibrium level at any point in time, but that they should be following the same trend in the long run. Temporary deviations from the equilibrium value (in the absence of rapid changes to the trend in the explanatory variables) can hence be ascribed to the effect of various other factors that are difficult to quantify and estimate in a model. These factors include unobservables such as emerging market risk aversion, currency speculation, international market crises, political uncertainties, etc.

6. The long-run properties of the VECM model

There is sufficient evidence of a single cointegrated long run equation between the explanatory variables and the real effective exchange rate. Closer inspection of the long-run properties (or elasticities) of the VECM model reveal the sensitivity of the exchange rate level to these factors. In fact, the long-run elasticities of the model can be extracted directly from the regression analysis shown in Table 3. Since the adjustment factor and half life of a shock also contains important information, the following graphs have been amended to illustrate the speed of convergence to the long run equilibrium, i.e. in the event of a shock. A short description of the long run properties of the model and a graphical depiction of their convergence to the long run equilibrium is provided below[10].

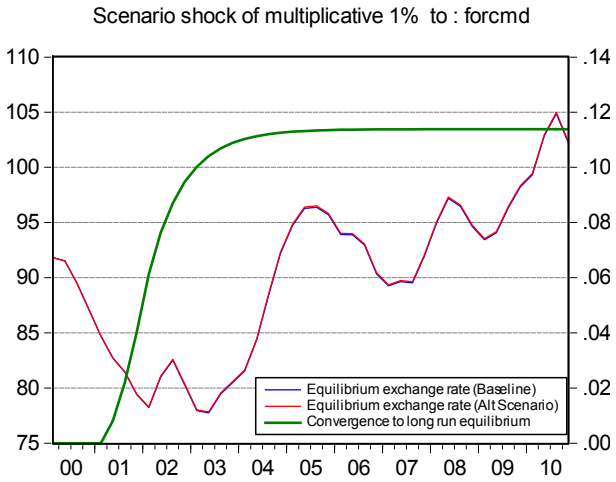


An increase of 1 percentage point (100 bps) in the real interest rate differential would tend to appreciate the real effective exchange rate of the rand by around 0,8 per cent in the long run.

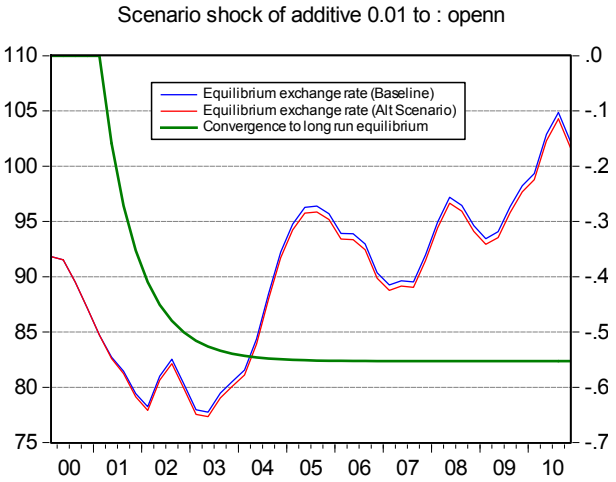


An increase of 1 per cent in South Africa's real GDP per capita relative to that of its trading-partner countries would be associated with an appreciation of the real effective exchange rate of approximately 1,3 per cent in the long run.

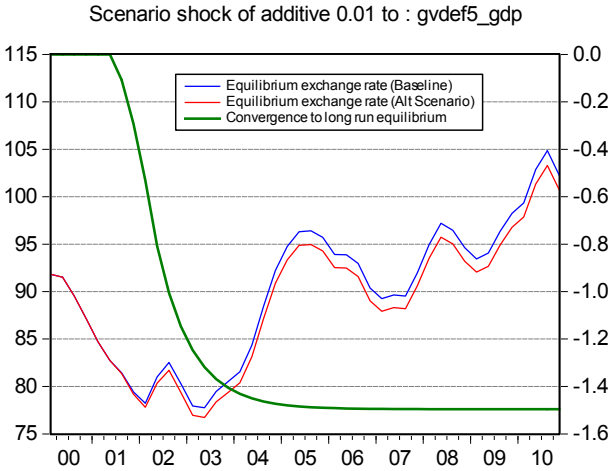
[10] The impulse response imposes a shock to the model, for example, a 1 per cent shock to the level, or 1 percentage point in the case of a ratio to GDP or interest rate adjustment shock. This trend exhibits a gradual convergence to the estimated long-run elasticity estimated in the regression analysis.



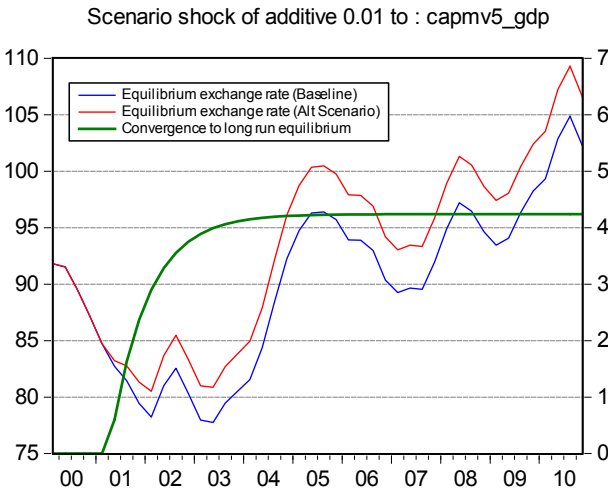
The results of the VECM show that an The increase of commodity prices relative to oil of 1 per cent is associated with an appreciation of the real effective exchange rate of slightly more than 0,1 per cent in the long run. This elasticity appears to be relatively small but could be ascribed to the fact that the commodity prices enter the equilibrium as a ratio to imported oil prices.



An increase in the trade liberalisation or the general openness of the South African economy by 1 percentage point of GDP is associated with a depreciation of real effective exchange rate of slightly more than 0,5 per cent in the long run



The Government deficit (fiscal balances) have a pronounced effect on the equilibrium real effective exchange rate. The model suggests that a one per cent improvement in the deficit or decline in the public sector borrowing requirement (i.e. as a percentage of GDP) is associated with a rate of depreciation of the real effective exchange rate of around 1,5 per cent



Capital movements (not surprisingly) were found to play an important and integral role in real effective exchange rate determination. The results of the estimated model reveal that an increase of 1 percentage point in the combined capital movement variable as a ratio to GDP will lead to an appreciation of the real effective exchange rate of more than 4 per cent.

These few graphs illustrate the sensitivity of the exchange rate to the explanatory variables of the model, as well as the fairly quick convergence to the long run. The graphs also reveal that capital flows and the government's fiscal balances play a major role when determining the equilibrium exchange rate. The elasticity of the commodity price seems surprisingly low at 0,1 and it may be worthwhile to analise this relationship more closely (i.e. to see if it is robust over different time periods), especially since South Africa is generally regarded as a major commodity producer and exporter.

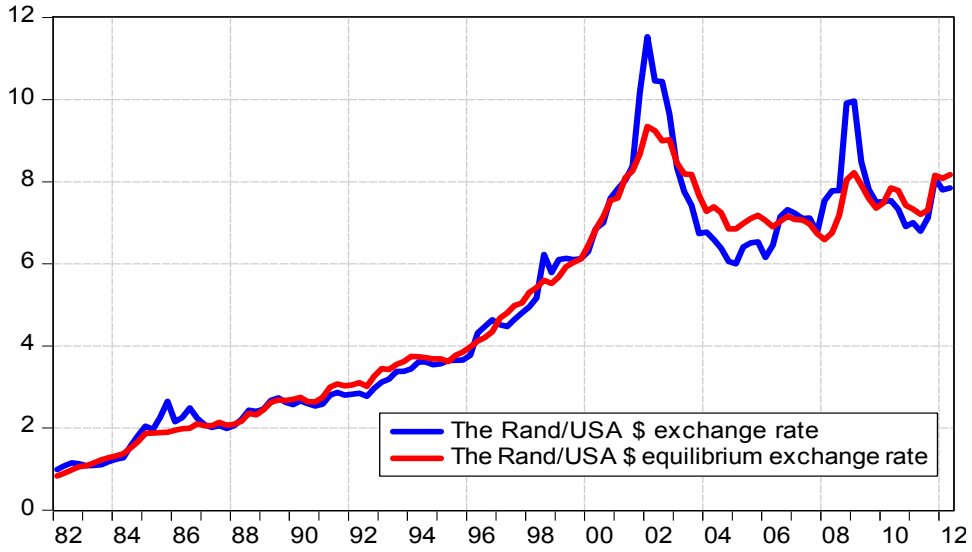
7. Equilibrium implications for the nominal rand/dollar exchange rate

One of the aims of this study is to determine the extent of the misalignment of the actual Rand/USA dollar exchange rate from its equilibrium level. This is achieved by converting the real equilibrium exchange rate back to a nominal effective by means of the purchasing power parity (PPP) differential. Then the equilibrium level of the nominal effective exchange rate of the rand is inverted and adjusted by a variable factor to generate the equilibrium level of the Rand/USA dollar exchange rate. Therefore, for consistency, both the PPP differential and factor is assumed to be the one that prevails over the estimate period to generate the real exchange rate in the first place.

The graph shown in Figure 3 illustrates the actual level and the derived level of the equilibrium rand/dollar exchange rate. This graph furthermore shows the gradual, yet consistent rate of depreciation from roughly R2 to the USA dollar during the early 1980s to slightly less than R12 to the USA dollar during the first quarter of 2002. Thereafter the exchange rate appreciates to stabilise between R/$6.00 and R/$7.00 over the 2004 to 2007 period. The global financial crises and emerging market risk aversion saw the R/$ exchange rate depreciate to a value of approximately 10R/$ towards the end of

2008 and early 2009 period. As expected, the equilibrium R/$ exchange rate was far less severe than the actual pace of depreciation over this period. Lastly, the equilibrium model signifies that the actual level of the R/$ exchange rate (R8.09) should have been trading close to its equilibrium at roughly R8.15 to the USA dollar during the last quarter of 2011, i.e. before showing a moderation to R8.08 in the first quarter of 2012. This equilibrium level for the first quarter of 2012 nevertheless suggests a further widening in the gap from 1 per cent in the fourth quarter of 2011 to an estimated 3½ per cent overvaluation of the R/$ exchange rate in the first quarter of this year.

Figure 3 : The equilibrium level of the nominal rand/dollar exchange rate



Since preliminary data is used, the first quarter of 2012 should be considered a rough estimate for the equilibrium level. It is also important to note that this is the equilibrium from the given set of fundamentals, and a different equilibrium level would be generated if the model was defined differently. Secondly, it might also be worthwhile to test the robustness of the variable parameters over different time periods to ensure that the parameters are indeed stable. This would also help to add credence to the level of the equilibrium since it still remains an unobservable and is therefore prone to much debate on its true level.

8. Concluding remarks

The South African Reserve Bank states there is no target for the exchange rate and that the level of the currency is determined by the market forces via the supply and demand for domestic currency. The SARB's intervention in the foreign exchange market may well influence the value of the currency over the short term, but the movement in key economic fundamentals primarily dictate the actual level of the exchange rate over the

longer term. The trend in the economic fundamentals therefore play a major role in determining the level of the equilibrium exchange rate.

The recent trend in South Africa's real effective exchange rate has raised concerns that the value of the currency may have diverged from its fundamentals. This assertion hence requires an adequate measurement of the equilibrium exchange rate. The equilibrium level can then be used to ascertain whether the actual real effective exchange rate is above or below its equilibrium, i.e. whether there is an overvaluation or undervaluation of the currency respectively.

This study estimates a VECM model to generate a long-run equilibrium level of the real effective exchange rate by separating the long-run cointegrating equation from its short-run VAR dynamics. The actual levels deviation from this equilibrium can then be used to define the magnitude of over or undervaluation of the currency. The main determinants of the real effective exchange rate of the rand follows the most relevant theoretical models, and includes key economic fundamentals such as the real interest rate differential, a relative productivity measure between South Africa and its trading-partner countries, commodity prices, the size of the fiscal balance, a measure of the country's openness and the capital flows to South Africa.

The estimated results of the study suggest that the real effective exchange can deviate from its equilibrium during protracted periods of time. In fact the equilibrium level of the real effective exchange rate was roughly 20 per cent less depreciated when compared to the actual level of the exchange rate during the late 2001 and early 2002 period, which suggests that it was not the fundamentals that were driving the severe depreciation of the rand, but that it was rather the result (or consequence) of various other external factors including the speculation against the currency.

The analysis was extended to derive an equilibrium nominal value for the rand/USA dollar exchange rate. The model results suggest that the Rand/USA dollar rate was roughly 1 per cent overvalued during the last quarter of 2011, and that the currency should have been trading at a level of R8.15 to the USA dollar during this period.

Finally, it should be noted that this model merely illustrates the possible equilibrium level based on the given set of key economic fundamentals. While there may be clear indications that the exchange rate is inconsistent with its fundamentals, it does not necessarily imply that this equilibrium level can be viewed as the correct value without a doubt.

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Appendix

Table 4 : Codes, the definition and the source of variables used in the model

Codes	Definition of the variable	Source
EXREALD	Real effective exchange rate of the rand	SARB
RIRRUS	The real interest rate differential between South Africa (repo rate less manufacturing PPI inflation) and the USA (prime lending rate less foreign wholesale price inflation)	SARB
PRODDIFF	A relative manufacturing productivity measure between South Africa and the USA.	SARB IFS US Fed
FORCMD/OILPDD	The ratio of South Africa's export commodity price index (in US dollar terms) to South Africa's imported oil price index (contractual oil prices, in US dollar terms)	SARB
OPENN	A measure of trade openness defined as the sum of the real exports and imports of goods and services as a percentage of real gross domestic product	SARB
GVDEF5_GDP	The government's public sector borrowing requirement as a percentage of nominal gross domestic product (i.e. where the fiscal deficit is denoted by a negative balance)	Bank
CAPMV5_GDP	The change in capital transfer and financial accounts including unrecorded transactions, expressed as a percentage of the nominal gross domestic product (i.e. where both the net capital inflow is expressed as a positive)	SARB

Figure 4 : The dependent and explanatory variables of the VECM