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Bernard Njindan Iyke[1] and Nicholas M. Odhiambo

Abstract

In this paper, we identify the fundamental determinants of the long-run exchange rates in South Africa. We then estimate the equilibrium real exchange rate for this country using a dataset covering the period 1975-2012. In order to account for possible short-run fluctuations in the real exchange rate, we conducted a cointegration test using the ARDL bounds-testing procedure. First, we found terms of trade, trade openness, government consumption, net foreign assets and real commodity prices to be the long-run determinants of the real exchange rate in South Africa. Second, we found that nearly 68.06 per cent of the real exchange rate disequilibrium is corrected annually. Overall, the estimated equilibrium exchange rate indicates that the Rand has been depreciating in real terms over the years. Tightening trade openness is not an option, given international agreements; on the other hand, terms of trade and real commodity prices are determined by the world market. The obvious policy alternative is for South Africa to increase government spending and moderately decrease her net foreign asset position.

Keywords: *Fundamental Determinants, Real Exchange Rates, Equilibrium Exchange Rate, South Africa*

JEL Classification Code: *C53, F31*

1. Introduction

The exchange rate remains one of the most enigmatic variables in economic literature. Thus, monetary institutions around the world have been preoccupied with the issue of identifying the 'right' exchange rate policies for their economies. The literature has focused more on the

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definition, the appropriate measures, detection, and correction of the real exchange rate disequilibrium. These issues are central to realising and enhancing macroeconomic stability of any economy (see Edwards, 1996). In the case of developing countries, exchange rate remains ever dominant in policy discussions as it was even during the era of the 'Gold Standard' (see Melvin, 1985; Collins, 1996; Papaioannou, 2003 among others).

Several attempts have been made, in the literature, to determine what influences countries to opt for a particular exchange rate regime.[2] The optimum currency area (OCA) literature, for example, identified economic size and trade openness as long-run fundamental determinants of the choice of exchange rate regimes (see Mundell, 1961; McKinnon, 1963). Also, factors like capital and current account openness, and the structure of the foreign exchange and capital markets were also found to influence the choice of exchange rate regimes (see Frankel, 1995; Edwards, 1996; and Hausmann *et al.,* 2001). In other theoretical studies, political, historical, and institutional factors were found to influence the choice of exchange rate regimes (see Tornell and Velasco, 1995; and Berger *et al.,* 2000).

In most developing countries, different exchange rate regimes have been experimented with over the years. The IMF reports on exchange rate policy strongly indicate that most developing countries have changed their exchange rate regimes at least twice within the space of two decades, and particularly, in the 21st century. Indeed, sub-Saharan African countries have practised these exchange rate experiments in their exchange rate history. In this paper, we attempt to estimate the equilibrium real exchange rate for South Africa, using the real macroeconomic fundamental determinants approach and the ARDL bounds-testing technique for

[2] See Rogoff *et al.* (2003) for further discussion of the evolution of exchange-rate regimes.

cointegration. In addition, we provide a chronology of exchange rate events in South Africa since she became independent.

The rest of the paper is organised as follows: In Section 2, we present the chronology of exchange rate events in South Africa to date. In Section 3, we provide a brief review of the relevant literature on equilibrium real exchange rate. In Section 4, we present the econometric methodology, and the results of our estimations. In the final section, we provide the relevant conclusions.

2. The Chronology of Exchange Rate Events in South Africa from Independence to Date

Before independence in 1961, South Africa practiced various exchange rate mechanisms. For example, between 1921 and 1944, the country exchange rate was based on the gold standard. The South African Reserve Bank (SARB) was established in 1921; and in April 1922, the new currency, the South African pound, was issued and pegged at par with the British pound. Then, in December 1932, the SARB abolished the convertibility of the South African pound to gold (van der Merwe, 1996).

By 1944, the SARB had replaced the gold standard with a fixed exchange rate regime. The South African pound was pegged to the British pound and the US dollar, with occasional adjustments to correct misalignments until 1961, when the country became independent (see van der Merwe, 1996; Nel, 2000; Odhiambo, 2004). The exchange rate was originally fixed at 1 SA pound per US$4.03, and later devalued to 1 SA pound per US$2.80 in 1946. At independence in 1961, the South African rand replaced the South African pound. The exchange rate was fixed at 1 SA rand per US$1.40 in the same year; and it remained so until December 1971 (see van der Merwe, 1996; Odhiambo, 2004).

The South African rand was delinked from the US dollar and pegged to the British pound between December 1971 and October 1972, due to the strong depreciation of the dollar during that period. The country switched to the Smithsonian realignment, and devalued the rand by 12.3 per cent in December 1971. From October 1972 until January 1979, South Africa adopted a managed float regime with a parallel market. First, the rand was delinked from the British pound and pegged to the US dollar in October 1972. This system was later replaced in June 1974 by a managed float system, in line with the Rand Monetary Area (RMA) agreements. Three countries – South Africa, Lesotho, and Swaziland – formed the RMA in June 1974. Thus, South Africa officially replaced an independent exchange management with a managed float on signing the RMA agreements. Under these agreements, the SARB could only adjust the exchange rate to smooth out any fluctuations. The exchange rate was devalued in September 1975 by 17.5 per cent and fixed at 1 SA rand per US$1.15 until 1979.

In 1977, the De Kock Commission was established to review the exchange rate and monetary policies of the country. The commission submitted its findings to the government in November 1978. Following these findings, South Africa adopted a managed float regime, with dual exchange rates between January 1979 and February 1983 (see De Kock, 1985; van der Merwe, 1996; Odhiambo, 2004). The regime featured two exchange rates: the commercial rand and the financial rand. According to the recommendations of the De Kock Commission, the mandatory buying and selling rates for the US dollar were to be abolished (see van der Merwe, 1996; Odhiambo, 2004). Also, the SARB discontinued the announcement of its predetermined buying and selling rate of the US dollar, in February 1979 (see van der Merwe, 1996; Nel, 2000; Odhiambo, 2004). However, in February of the same year, the SARB introduced the managed float system without dual exchange rates. Further, the exchange controls on non-residents were abolished in the same year. The SARB decided to temporally suspend its exchange reforms, following the strong depreciation of the rand in 1985. Instead, the SARB tightened capital controls (Odhiambo, 2004).

South Africa would soon revert to a managed float system, with dual exchange rates in September 1985. The financial rand was reintroduced, whilst the Common Monetary Area (CMA) replaced the RMA in July 1986 (see van der Merwe, 1996; Odhiambo, 2004). In March 1992, the SARB bought and sold in financial rand transactions with the aim of exiting that market. The country decided to unify the dual exchange rates in March 1995; and consequently, it operated a unified floating regime from March 1995 until 1999. As part of the drift from the dual exchange rates to the unified floating system, the SARB exited from short-term transactions, and scrapped the financial rand in March 1995. From February 2000 to date, South Africa has been pursuing a fully floating exchange system.

3. Review of Related Literature

A large number of empirical studies have provided alternative measures for the estimation of the equilibrium real exchange rate.[3] The majority of these empirical studies were critical of the choice of the purchasing-power parity (PPP) procedure for estimating the equilibrium real

[3] A survey of earlier papers on the real exchange measurement and estimation could be found in MacDonald (1995), Rogoff (1996), and Hinkle and Montiel (1999). For a very recent survey, see Lee *et al.* (2008).

exchange rate. As pointed out by MacDonald and Ricci (2003), the PPP model suffers greatly from its slow mean-reverting property to a constant level–which is its implied long-run equilibrium assumption.

The common approaches, replete in the literature, which undermine the PPP approach, suggest that we identify the nexus between the real exchange rate and other fundamental macroeconomic variables. These studies proposed that we identify the fundamental determinants of the real exchange rate by specifying an appropriate model, within which the dynamic response of the real exchange rate to varied shocks could be examined (see Montiel, 1999).

Classically, the equilibrium exchange rate for a country could be established by setting up and simulating an empirical dynamic macroeconomic model, using parametric calibrations and data suitable for that country. This is the so-called general equilibrium approach in the literature. As Montiel (1997) argued, when an appropriate macroeconomic model is built for a country, Monte Carlo simulations on the specific policy paths and the exogenous determinants result in consistent steady-state values for the real exchange rate. Studies that have employed this procedure to examine the exchange rate equilibrium include those of Clark *et al.* (1994), Williamson (1994), and Stein *et al.* (1995).

Other researchers employed single equation models and partial equilibrium models to examine the real exchange rate equilibrium. The notable one in the literature is the "trade elasticities" approach – a partial equilibrium technique (see Montiel, 1999). Driver and Wren-Lewis (1997), for instance, have used this technique to estimate the real exchange rate equilibrium for the G7 countries. Ghei and Pritchett (1999) also used this technique in their study. Some researchers have, instead, employed reduced form equations to estimate the equilibrium real exchange rate.

This technique has often required that the fluctuation components of the real exchange rate be removed. A classic study, which employed this technique, was that of Edwards (1994) for a panel of 12 developing countries.

More recently, various studies have employed econometric techniques which sought to gain robust parameter estimates from the non-stationary properties of the macroeconomic determinants of the real exchange rate. Indeed, this is the so-called “cointegration approach” for estimating the equilibrium real exchange rate. The most notable empirical studies, which used this approach, include those of Elbadawi and Soto (1994), Cardenas (1997), Montiel (1997), Loayza and Lopez (1997), Aron *et al.* (2000), MacDonald and Ricci (2003), and Iman and Minoiu (2011).

In this paper, we employ the cointegration approach. Various variables have been identified in the literature in the estimation of the fundamental equilibrium real exchange rate. These variables include: world commodity prices (see Cashin *et al.*, 2002; Chen and Rogoff, 2002; MacDonald, 2002; MacDonald and Ricci, 2003), terms of trade (see Montiel, 1997; Goldfajn and Valdes, 1999; Imam and Minoiu, 2011), government consumption or spending (see De Gregorio *et al.*, 1994; Montiel, 1997; MacDonald and Ricci, 2003; Imam and Minoiu, 2011), size of the net foreign assets (see Lane and Milesti-Ferretti, 2000; MacDonald and Ricci, 2003; Imam and Minoiu, 2011), and trade openness (see Montiel, 1997; MacDonald and Ricci, 2003; Imam and Minoiu, 2011). These are the variables we have employed in this paper. One important innovation of our paper is that we incorporate the growth of the world economy in our estimation. Real exchange rates, especially in more open economies, are known to respond to the performance of the global economy.

4. Methodology and Results

4.1 The Econometric Technique

We have employed the autoregressive distributed-lag (ARDL) bounds-testing procedure proposed by Pesaran *et al.* (1996), Pesaran and Shin (1999), and Pesaran *et al.* (2001) to examine the long-run relationships between the real exchange rate and its fundamental determinants. This approach was preferred to other approaches for three reasons: (i) It can be applied, whether the time series are integrated of order zero, one, or a mixture of both; and (ii) it has better finite sample properties.[4]

The ARDL bounds-testing procedure requires that we employ the following general $ARDL$ equation, in terms of our variables:

$$
\begin{aligned}
\Delta lnREER_t = {} & \gamma_0 + \gamma_1 t + \sum_{i=1}^{q} \gamma_{1i}\, \Delta lnREER_{t-i} + \sum_{i=0}^{q} \gamma_{2i}\, \Delta lnTOT_{t-i} + \sum_{i=0}^{q} \gamma_{3i}\, \Delta lnOPEN_{t-i} + \sum_{i=0}^{q} \gamma_{4i}\, \Delta lnGCR_{t-i} \\
& + \sum_{i=0}^{q} \gamma_{5i}\, \Delta lnNFAR_{t-i} + \sum_{i=0}^{q} \gamma_{6i}\, \Delta lnRCPI_{t-i} + \sum_{i=0}^{q} \gamma_{7i}\, \Delta lnWGDPG_{t-i} + \delta_1 lnREER_{t-1} + \delta_2 lnTOT_{t-1} \\
& + \delta_3 lnOPEN_{t-1} + \delta_4 lnGCR_{t-1} + \delta_5 lnNFAR_{t-1} + \delta_6 lnRCPI_{t-1} + \delta_7 lnWGDG_{t-1} \\
& + \mu_t \qquad (1)
\end{aligned}
$$

Where μ, γ, and δ are, respectively, the white-noise error term, the short-run coefficients, and the long-run coefficients of the model; and Δ is the first difference operator. In addition, *t* denotes time period; q is the maximum number of lags in the model.

From *Equation (1)*, there exist cointegrating relationships between the series, if at least one of the δs is significantly different from zero. Otherwise, we could reject the evidence of

[4] See Pesaran *et al.* (1996), Pesaran and Shin (1999), and Pesaran *et al.* (2001), for extensive discussion.

cointegration between real exchange rate, in particular, and the fundamental determinants; since any other possible evidence of cointegration would not be relevant to our study.

We note that the ARDL bounds-testing procedure for cointegrating relationships follows a non-standard asymptotic *F*-distribution. Two sets of critical values have been constructed by Pesaran *et al.* (2001) under this null hypothesis. The first set of critical values is constructed under the assumption that variables in the ARDL model are integrated of order zero, *I(0)*. The second set of critical values is constructed under the assumption that variables in the model are integrated of order one, *I(1)*. We do not reject the null hypothesis of no cointegration relationships when the *F*-statistic falls below the lower-bound values. Similarly, we reject the null hypothesis of no cointegration when the calculated *F*-statistic is greater than the upper-bound values. However, the test is inconclusive, when the *F*-statistic falls between the lower and upper bounds.

4.2 The Estimated Equilibrium Real Exchange Rate for South Africa

The fundamental determinants of the equilibrium real exchange rate in South Africa were extracted, based on the empirical literature discussed earlier. We extracted the real effective exchange rate (REER), the ratio of government consumption to GDP (GCR), trade openness (OPEN)[5], terms of trade (TOT)[6], net foreign assets to GDP (NFAR), and the world economic growth (WGDPG) from the World Development Indicators (WDI), 2014. The data on real commodity price index (RCPI) were extracted from the Global Economic Monitor (GEM) Commodities, 2014.

[5] This ratio is measured as the sum of exports and imports of goods and services to GDP (in 2005 constant US$).

[6] This ratio is measured as imports divided by exports of goods and services (see Obstfeld and Rogoff, 1996).

As a preliminary analysis, prior to estimating the equilibrium real exchange rate for South Africa, we examined the stationary properties of the variables. We employed the Dickey-Fuller Generalized Least Squares (DF-GLS) and the Ng-Perron tests, proposed by Elliot *et al.* (1996), and Ng and Perron (2001), respectively. Our choice was influenced by the fact that the canonical tests for stationarity (such as the ADF and PP tests) have been found to reject the null hypothesis of unit root, when the time series under consideration has a large and negative moving average (MA) component, even when there is a unit root (see Schwert, 1986; Caner and Killian, 2001). Elliot *et al.* (1996), and Ng and Perron (2001) demonstrated, respectively, that the DF-GLS and the Ng-Perron tests have substantially higher power, even when the root of the time series is closer to unity.

We performed unit root tests on these variables and found that all, except WGDPG, were stationary after first difference. WGDPG was level-stationary at 1 per cent significance. Trend was not included in each of the tests, as the graph of the variables[7] did not indicate any significant trending phenomenon. We limited our lag choice to a maximum of 4, using the Modified Akaike Information Criterion (MAIC). This choice was informed by the small size of our dataset. The results for the unit root test are reported in Table 1.

[7] See Appendix A, Figure 1 for the graphs.

Table 1: Tests for Unit Roots of the Variables

Variable	DF-GLS t-statistic	Ng-Perron MZ_a-statistic
LNREER	-1.2250	-3.3696
ΔLNREER	-4.7475***	-17.4732***
LNGCR	-0.7778	-1.7475
ΔLNGCR	-3.3216***	-15.3402***
NFAR	-0.4012	-1.3277
ΔNFAR	-1.7718*	-12.7216**
LNOPEN	-0.5657	-1.0457
ΔLNOPEN	-4.3063***	-16.3663***
LNRCPI	-0.1372	-0.1150
ΔLNRCPI	-3.9805***	-15.5254***
LNTOT	-1.2862	-3.3915
ΔLNTOT	-3.1358***	-16.5585***
WGDPG	-3.9480***	-15.3927***

Note:
(i) The DF-GLS statistic is based on MacKinnon (1996).
(ii) The Ng-Perron statistic is based on Ng and Perron (2001, Table 1).
(iii) *, **, and *** denote significance at 10%, 5%, and 1%, respectively.
(iv) Δ is the first difference operator.

As the next step, we established the optimal lag of the ARDL model using the AIC. The optimal lag chosen was at most 2. We then performed the ARDL bounds-testing technique for cointegration, after examining the unit root properties of the time series. The results show that there is evidence of cointegrating relationships between the real exchange rate and the other macroeconomic variables. The calculated *F*-statistic (3.96) was found to be greater than the upper bound critical value (3.61) at the 5 per cent level of significance. The result of the ARDL bounds test is shown in Table 2.

Table 2: ARDL Bounds Test for Co-integration

Dependent Variable	Function			F-statistic		
lnREER	*lnREER(lnGCR, lnOPEN, lnTOT, lnNFAR, RCPI, WGDPG)*			3.96**		
Asymptotic critical values for unrestricted intercept and no trend reported from Table CI(iii) p. 300 of Pesaran et al. (2001)	1%	1%	5%	5%	10%	10%
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
	3.15	4.43	2.45	3.61	2.12	3.23

Note: ** denotes significance at the 5% level.

Having established the existence of cointegrating relationship in the series, we proceeded to estimate the equilibrium real exchange rate in two stages. In the first stage, we estimated the general short- and long-run models (which are not shown here). In the second stage, we sequentially deleted the variables which were not statistically significant in the long run until we arrived at parsimonious short- and long-run models. The results of the parsimonious models are presented below:

$$lnREER_t = 8.18 - 1.75lnOPEN_t - 2.58lnTOT_t + .93lnGCR_t - .50lnRCPI_t - .34NFAR_t \quad (2)$$

$$[4.58^{***}] \ [-5.36^{***}] \quad [-4.93^{***}] \quad [2.26^{**}] \quad [-2.07^{**}] \quad [-3.12^{**}]$$

$$\Delta lnREER_t = -.68ECM_{t-1} - 1.19\Delta lnOPEN_t - .91\Delta lnTOT_t + .63\Delta lnGCR_t + .38\Delta lnRCPI_t + .49\Delta lnRCPI_{t-1} - .06\Delta NFAR_t$$

(3)

$$[-5.01^{***}] \quad [-5.57^{***}] \quad [-3.40^{***}] \quad [2.42^{**}] \quad [3.48^{***}] \quad [2.70^{**}] \quad [-1.39]$$

The long- and short-run relationships between the equilibrium real exchange rate and its fundamental determinants are shown in *Equations (2)* and *(3)*, respectively. All the variables included in the estimation of the equilibrium real exchange rate, apart from the growth of the world economy, WGDG, were found to be significant.[8] The results show that, in the long run, assuming other determinants remain unchanged: (i) A percentage increment in trade openness leads to around 1.75 per cent real depreciation of the exchange rate; (ii) a percentage increment in terms of trade leads to around 2.58 per cent real depreciation;[9] (iii) a percentage increment in government consumption leads to around 0.93 per cent real appreciation;[10] (iv) a percentage increment in real commodity prices results in about 0.50 per cent real depreciation; and (v) a percentage increment in net foreign assets leads to approximately 0.34 per cent depreciation of the real exchange rate.[11] The results also show that nearly 68.06 per cent of the real exchange rate disequilibrium is corrected annually. The speed of adjustment is, thus, considerably faster.

Conventionally, the estimated equations must pass the stability tests for inferences stemming from them to be taken seriously. Therefore, the stability of the parameters in these equations was examined using the cumulative sum of the recursive residuals (CUSUM) and the cumulative sum of the squares of recursive residuals (CUSUMSQ) tests proposed by Brown *et al.* (1975). The CUSUM and CUSUMSQ tests implemented show that this estimated equilibrium model is dynamically and structurally stable. The results of the stability tests are shown in Figures 1 and 2.

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[8] The t-statistics are shown in the parenthesis; **, and *** denote 5% and 1% significance level, respectively.

[9] Lee *et al.* (2008), and Imam and Minoiu (2011) found similar results in their studies.

[10] See Montiel (1997), and Imam and Minoiu (2011) for similar findings.

[11] MacDonald and Ricci (2003) found the opposite in their study on South Africa.

Figure 1: Plot of Cumulative Sum of Recursive Residuals (CUSUM)

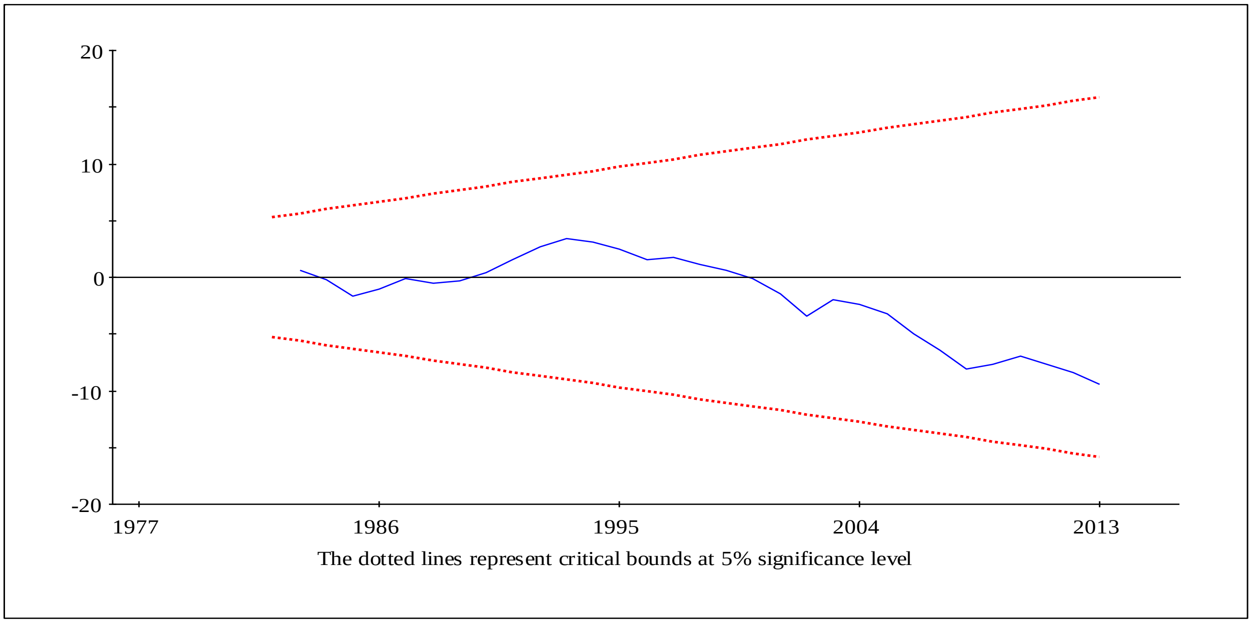
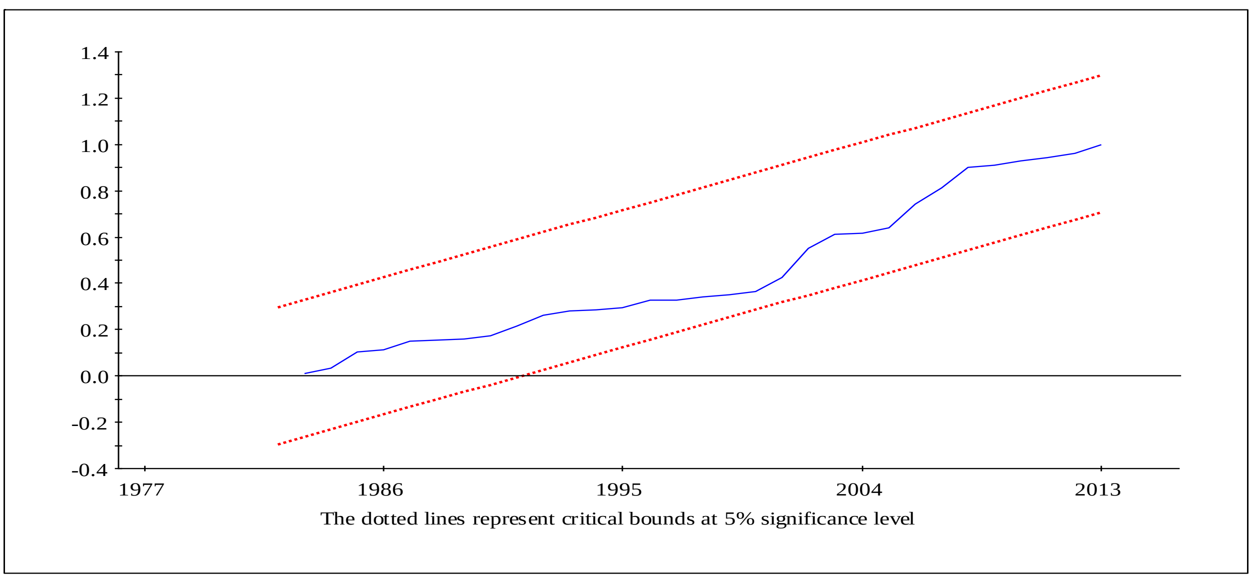
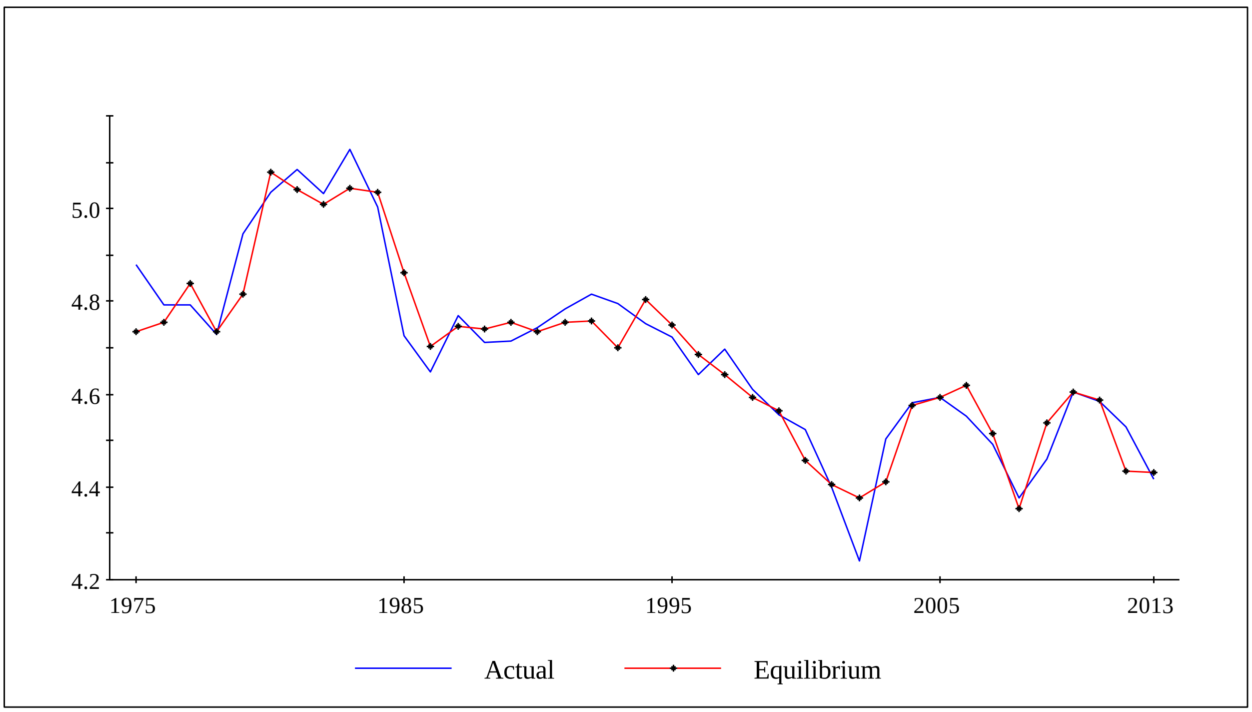


Figure 2: Plot of Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ)



Since the estimated short- and long-run equations are stable, the next step is to plot the equilibrium real exchange rate. The definition of equilibrium exchange rate, in this sense, is the measure of real exchange rate that is consistent with the long-run values of the fundamental determinants. The fluctuation component of the equilibrium real exchange rate was filtered, using the Hodrick-Prescott (HP) filter[12] time series decomposition technique. This was done to neutralize the effects of noise or the cyclical components of the fundamental determinants on the estimated equilibrium real exchange rate. Figures 3 and 4 depict the plotted equilibrium real exchange rate (unfiltered and filtered, respectively) against the actual real exchange rate. Figure 3 shows the plotted equilibrium gap, defined as the difference between the actual real exchange rate and the filtered equilibrium rate. From Figures 4 and 5, the actual real exchange rate seems to be approximately close to the equilibrium real exchnage rate over the sample period 1975-2013.

Figure 3: Plot of Actual against Equilibrium Exchange Rate



[12] See Appendix B for notes on the Hodrick-Prescott filter which was advanced by Hodrick and Prescott (1997).

Figure 4: Plot of Actual against the Hodrick-Prescott filtered Equilibrium Exchange Rate

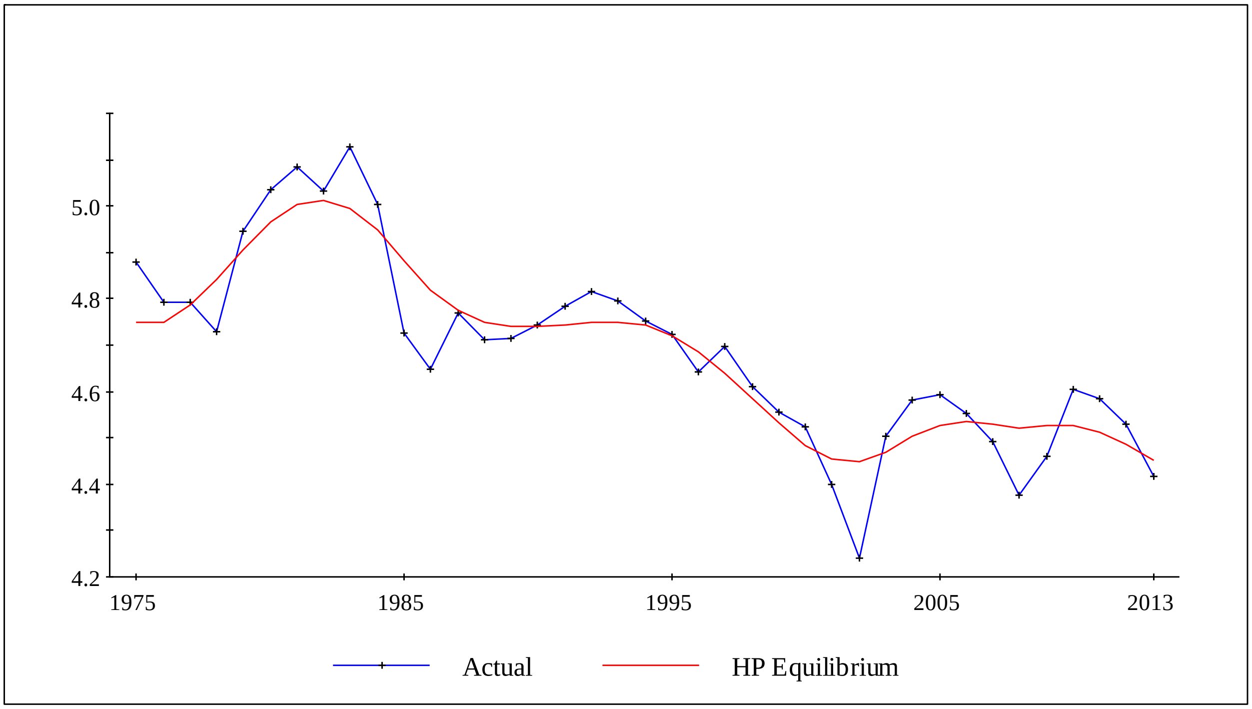


Figure 5: Plot of Equilibrium Gap (Actual minus HP filtered Equilibrium)

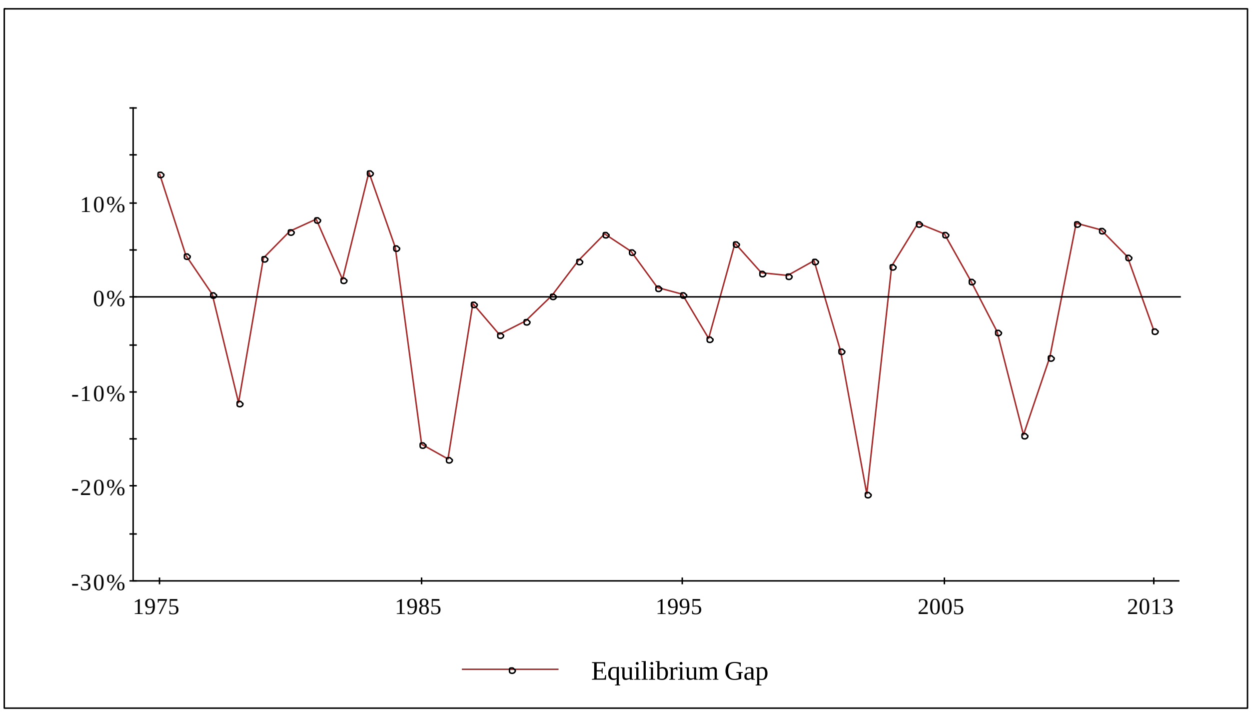


Figure 5 indicates that the highest gap recorded over the sample period was around 22 per cent real undervaluation in 2002. The overall impression of the estimated equilibrium rate is that the Rand has been losing its value over the years. The sharp appreciation of the Rand in the mid-1970s and the early-1980s could be attributed to government consumption, which increased during the period. The depreciation of the Rand, after 1983, could be mainly attributed to the trade liberalisation policies that were pursued during and after this period. We note that, though the actual rate has deviated sometimes from the equilibrium level, the adjustment factor of 0.681 implies that these temporary deviations are covered rapidly on a year-on-year basis.

5. Conclusions

The exchange rate has remained one of the most widely discussed variables in the global economy. Central to the dominance of this macroeconomic variable is that frequent exchange rate misalignments are generally seen as detrimental to current and capital account balance, and to the accumulation of external reserves. Moreover, the real exchange rate has strong links with other crucial macroeconomic variables, such as inflation and the real interest rate. Thus, policymakers cannot undertake any meaningful short- or long-term projections without incorporating this variable. One of the widely recognized ways of tracking the real exchange rate is by examining its steady-state or equilibrium properties. In this way, policy-makers could determine whether the actual real exchange rate has been moving along the desired path. In the past, researchers have employed the PPP procedure to track the movement of the real exchange rate over time.

However, most recent studies have found the PPP procedure to be inappropriate, due to its slow mean-reverting property. The widely favoured method in the recent literature is the fundamental equilibrium approach. In this paper, we estimated the equilibrium real exchange rate for South Africa employing the fundamental equilibrium real exchange rate approach. Unlike most of the previous studies, we employed the ARDL bounds-testing procedure, which has better small-sample properties. In addition, we explored the chronology of exchange rate events in South Africa since independence. Our results show that the fundamental determinants of the equilibrium real exchange rate in South Africa are terms of trade, trade openness, government consumption, net foreign assets and real commodity prices. The actual real exchange rate appeared closer to the estimated equilibrium rate in South Africa. However, the Rand has depreciated in real terms on year-on-year bases after the 1983. This may be due to the drastic trade liberalisation policies that were pursued during and after this period. Tightening trade openness is not an option, given international agreements; on the other hand terms of trade and real commodity prices are beyond the control of South African policies, since they are determined by the world market. The obvious policy alternative is for South Africa to increase government spending and moderately decrease her net foreign asset position. Finally, the speed of adjustment, when the actual real exchange rate deviates from its equilibrium level, is faster in South Africa. Indeed, the estimated adjustment factor of 0.681 implies that temporary deviations are covered rapidly on a year-on-year basis. In other words, nearly 68.06 per cent of the real exchange rate disequilibrium is corrected annually.

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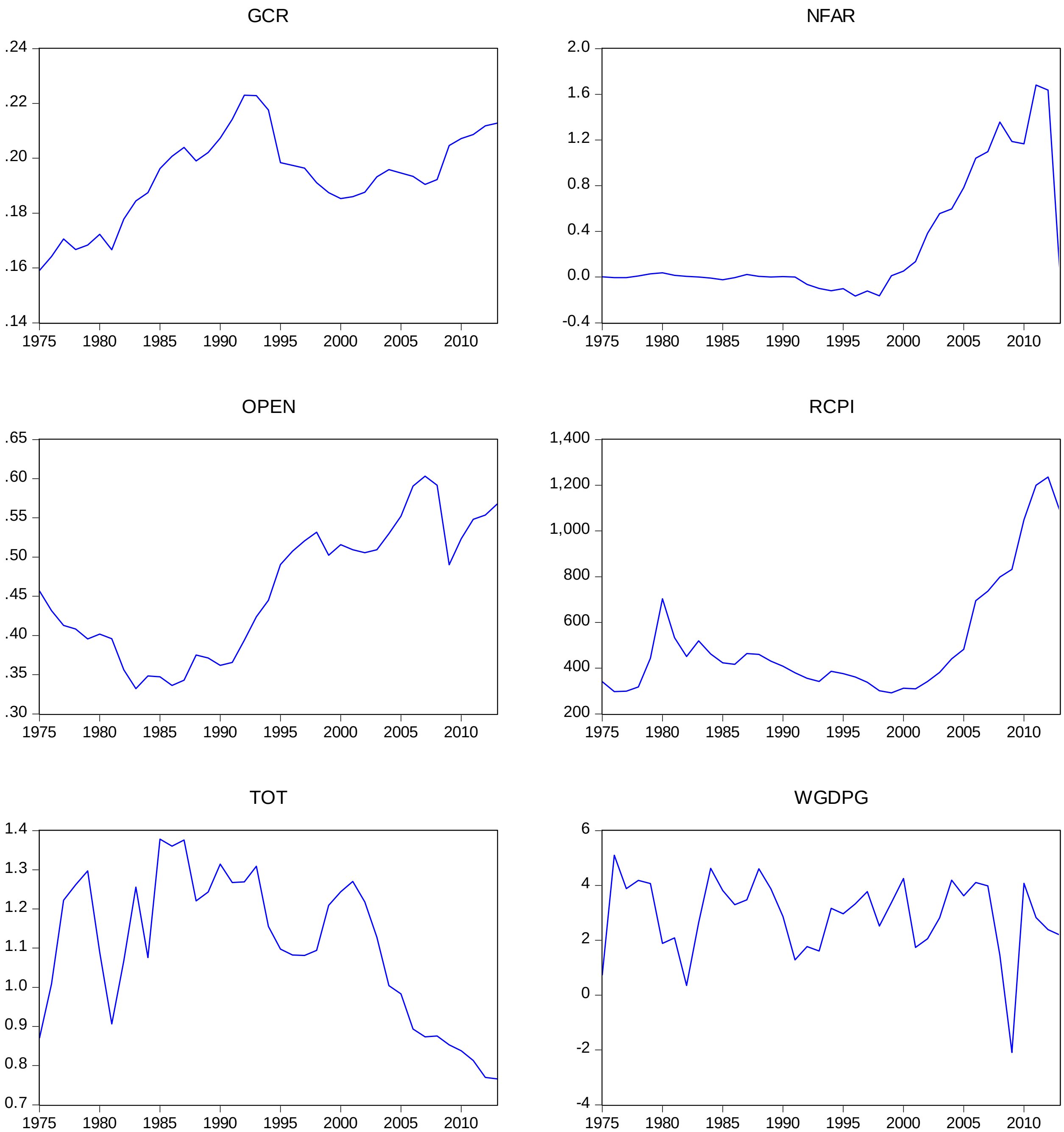
APPENDIX A

Figure 1: The Fundamental Determinants of Real Effective Exchange Rate in South Africa (1975-2013)



Source: Constructed by Authors from WDI (2014) and GEM Commodities (2014).

APPENDIX B

Some Notes on the Hodrick-Prescott Filter

The Hodrick-Prescott (HP) filter or decomposition is a technique employed in macroeconomics and macroeconometrics to decompose a time series into cyclical and trend components. The technique was proposed by Whittaker (1923). But it was not until the seminal paper of Hodrick and Prescott (1997), when the HP-filter gained immense recognition. The main importance of the HP-filter lies in its ability to provide a smooth-curve representation of a time series which is susceptible to long-run impacts than cyclical fluctuations.

The HP-filter is derived on the basis that a time series, say x_t , could be decomposed into a trend (τ_t) and cyclical component (c_t). Assuming, from this intuition, that $x_t = \tau_t + c_t + \mu_t$, where μ_t is the error term of the time series at period *t*. Then, there exist a positive value of a multiplier λ, such that τ solves the minimization problem:

$$\min_{\tau}\left(\sum_{t=1}^{T}(x_t - \tau_t)^2 + \lambda\sum_{t=2}^{T-1}[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2\right)$$

According to Hodrick and Prescott (1997), the sum of the squared deviations $d_t = x_t - \tau_t$ penalizes the short-run fluctuations in the time series. The second term is a multiple of the multiplier (λ) and the sum of squares of the second differences in the trend component of the series. This term penalizes deviations in the growth of the trend component of the time series. Higher values of λ entails higher penalties. For quarterly data, Hodrick and Prescott (1997) suggest that λ=1600 should be chosen. Ravn and Uhlig (2002) proposed we choose $\lambda = 6.25$ and 129600 for annual and monthly data, respectively.