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Abstract:

The study estimates the equilibrium exchange rate for Zambia for the period 2004Q1 to 2017Q2 based on the Behavioural Equilibrium Exchange Rate (BEER) approach and computes the extent to which the actual exchange rate deviates from its long run equilibrium level. The model is estimated under an error correction framework that accounts for structural break in the dependent variable. The study finds that net foreign assets, productivity differential, interest rate differential and the nominal exchange rate are significant determinants of the real effective exchange rate. The study also finds evidence of misalignment over the period with overvaluations accounting for a significant share. On average, the exchange rate was found to be overvalued by 1.574 percent over the period.

JEL classification: F31
Key words: Exchange rate; Equilibrium; Misalignment

[1] Corresponding author. E-mail address: fchansa@boz.zm. The study also benefitted from comments received from the editors of the BoZ Working Paper Series and the Technical Committee discussions held with Bank of Zambia staff. The findings and opinions expressed in this paper are entirely those of the author and do not in any represent the views or position of the Bank of Zambia.

Contents

1. Introduction

The real exchange rate is an important variable that embodies and conveys important information about relative prices in the economy. Movements in the real exchange rate are generally consequential for the entire economy as it affects the external competitiveness of the economy. According to Ajevskis et al (2012), movements in the real exchange rate should not depart significantly and persistently from its equilibrium level determined by economic fundamentals so that relative prices remain close to equilibrium over time and country's external position is sustainable. This deviation of the exchange rate from the long run or equilibrium exchange rate is what is referred to as exchange rate misalignment. Misalignment implies that the exchange rate is either overvalued or undervalued, both of which may have a negative impact on the economy when prolonged. This is because an overvalued real exchange rate can make an economy vulnerable to speculative attacks and currency crisis while an undervalued real exchange rate can lead to rising prices and resource misallocation between tradable and non-tradable goods (Essien, Uyaebo and Omotsho- 2017).

Therefore, the equilibrium exchange rate serves to acquire a benchmark that is used to check for the possible misalignment of the actual exchange rate and as such empirical estimates of this measure have been cited by many policy makers and academicians alike (Gandolfo, 2016). Advocates of this measure find it appealing because it conveys useful information on where the current exchange rate stands relative to some longer term measure of equilibrium and thereby shading light on likely future movements in the exchange rate. Moreover, in the formulation of appropriate policy response, the estimation of equilibrium exchange rates allows policy makers to know which are the most likely shocks to account for the observed exchange rate movement2. In literature, the concept of equilibrium exchange rate goes beyond the definition of a simple market equilibrium exchange rate which balances demand and supply of a currency in the absence of government intervention. Equilibrium exchange rate is defined as the exchange rate which is compatible with the economy being at internal and external balance in the medium term. The IMF argue that exchange rate assessments should ideally be based on a notion of equilibrium such as consistency with external and internal balance over the medium to long run (IMF 2006).

Over the past two decades, Zambia has experienced notable movements in the exchange rate which has seen the currency strengthen in some years and weaken in others on account of both domestic and external factors. Overall, the fluctuation in economic performance which has seen high growth rates in some years and low growth rates in others is likely to have led to a build-up of imbalances over time. In view of this, it is important to estimate the equilibrium real exchange rate of Zambia in order to assess if the real effective exchange rate has remained close to its equilibrium after the fluctuations observed over past few years.

In empirical studies, estimating the degree of exchange rate misalignment poses a number of challenges and chief among them is the fact that the equilibrium value of the real exchange

[2] Driver and Westaway (2003) argue that equilibrium exchange rate is also useful in fixed exchange rate arrangements such as monetary unions, when trying to decide whether a particular entry rate will be costly to sustain.

rate is not directly observable. However, standard economic theory postulates that the equilibrium real exchange rate is a function of observable macroeconomic variables and that the actual real exchange rate approaches the equilibrium rate over time (Williamson 1984, Edwards 1989 and Montiel 1997). Thus it is possible to estimate the equilibrium exchange rate with an appropriate model and there are a number of approaches that have been developed in literature. Generally speaking, the estimation approaches can be put into two broad categories. The first category consists of approaches involving structural models where internal and external balances are assumed to hold. The most common representation of this category is the so called Fundamental Equilibrium Exchange Rate (FEER) approach. The second category consists of direct estimation approaches where the equilibrium real exchange rate is obtained by estimating reduced-form equations in which the real exchange rate is specified as a function of fundamental determinants. Here there is no reference to internal or external equilibrium of the economy and the most popular representation of this category is the Behavioural Equilibrium Exchange Rate (BEER).

In this study, we attempt to estimate the equilibrium real exchange rate using the BEER approach and to determine the extent of misalignment over the period 2004Q1 to 2017Q2. The BEER has had wide application is estimating equilibrium exchange rate in developing countries.

2. Review of Empirical Literature

There has been a substantial amount of studies aimed at determining the equilibrium exchange rate in both developed and developing countries using different approaches. Most of these studies have proceeded to compute the degree of misalignment suggested by the level of exchange rate. In this section we review studies that have employed either the BEER or FEER approaches.

Mkenda (2001) conducted a study to establish the main determinants of the real exchange rate in Zambia and to estimate the extent of the real exchange rate misalignment over the period 1965 to 1996. Using the FEER approach, she estimated the exchange rates for imports and exports as well as an internal real exchange rate. The study found that the real exchange rates were overvalued and undervalued for a number of episodes. The most notable periods were the overvaluation between 1978 and 1984 in the real exchange rate for imports, and between 1982 and 1985 in the real exchange rate for exports. This overvaluation preceded the introduction of the auctioning system for foreign exchange. There was undervaluation of the exchange rate for imports in the period between 1987 and 1990 which was attributed to the severe depreciations following the abandoning of the auction system.

You and Sarantis (2011) did a study to determine the equilibrium Chinese-Yuan/US-Dollar exchange rate using the FEER approach. The study examined a complete set of trade equations and investigated the sustainable current account using an approach that highlighted the medium term macroeconomic determinates on savings and investments. They incorporated the Gregory and Hansen (1996) cointegration test to account for structural breaks. The study found that the yuan-dollar real exchange rate was overvalued from the early 1990's until 2003 especially during the Asian financial crisis and China's early World Trade Organization accession in 2001. Additionally, there was persistent undervaluation between 2004 and 2009 at an average of 28.5%. The misalignment rates were computed using a sustainable current account of 3%. Generally, overvaluations and under valuations coincided with periods of financial crises or economic uncertainty in China. Comunale (2017) did a study on the impact of real effective exchange rate misalignment using a panel of 27 EU countries over the period 1994 to 2012. He used the BEER approach and included a number of variables such as the foreign net capital inflows, the Terms of Trade and the Balassa-Samuelson effect represented by real GDP per capita of a country relative to the partners. He divided the countries into Core3 and peripheral countries. He found that the core currencies were slightly undervalued while countries on the periphery were overvalued starting from 2003 to 2004. New members of the EU however, experienced real overvaluations for the entire time span. The results seemed to be generally driven by the inflows of bank loans more than by foreign direct investments or portfolio investments. Ultimately, the study found that misalignments' persistence varied according to the group of countries considered. Basically, permanent misalignments were only found in new member states from the 2000s.

Essien et al (2017) conducted a study to determine the equilibrium real exchange rate of the Naira using the BEER approach over the period 2000 to 2016. He incorporated structural breaks and the Balassa Samuelson effect that was proxied by GNP per capita. Other determinants included the nominal exchange rate, total government expenditure and the interest rate differential. The results showed that on average, the Naira was overvalued by 0.15% in real terms over the study period. Generally, of the 64 quarters included in the sample, there were 43 episodes of overvaluation and 21 episodes of undervaluation depicting the dominance of overvaluation. The study also notes that there were four periods of prolonged exchange rate overvaluation whereas the episodes of real exchange rate undervaluation were relatively short, not exceeding two quarters. This suggests that the country was more tolerant of exchange rate overvaluation than exchange rate undervaluation. Furthermore, the study discovered a clear relationship between exchange rate misalignment and exchange rate regime.

Lossifov and Loukoianova (2007) estimated a BEER model for Ghana and their regression results showed that most of the real effective exchange rates long run behaviour can be explained using real GDP growth, real interest rate differentials and the real export prices of Ghana's main export commodities. They found that at the end of the third quarter of 2006, the actual real exchange rate appeared to be close to its estimated equilibrium level. The steep depreciation that occurred in 1999 to 2000 brought it significantly below the estimated equilibrium value and the gradual depreciation thereafter could be viewed as a return to a consistent level with macroeconomic fundamentals.

Aliyu (2007) estimated the BEER of the naira for the period 1986 to 2006 using well defined macroeconomic fundamentals for Nigeria. He used a number of determinants such as net foreign assets, terms of trade, index of crude oil price volatility and the index of monetary

[3] The core countries refer to Austria, Belgium, Denmark, Sweden, France, Germany and the UK.

policy performance. The BEER indicated that the naira was close to its predicted values dictated by the fundamental variables in the long run. However, the study identified four episodes each of overvaluation and undervaluation of the real exchange rate. In particular, real exchange rate was found to be overvalued from the second quarter of 1989 to the second quarter of 1995. Conversely, the real exchange rate was undervalued between the fourth quarter of 2001 and the fourth quarter of 2006.

3. Methodology and Analytical Framework

In this section we present the analytical framework used to estimate the equilibrium real exchange rate, the model specification and variable definitions.

3.1. Theoretical Framework

The Behavioral Equilibrium Exchange Rate (BEER) approach to estimating the equilibrium exchange rate rests on the use of a directly estimated reduced form equation that explains the behavior of the real effective exchange rate as a function of fundamental determinants. This reduced form equation can be written as follows:

$$q_t = \beta_1' Z_{1t} + \beta_2' Z_{2t} + \tau' T_t + \varepsilon_t \quad (1)$$

where Z_{1t} and Z_{2t} are vectors of economic fundamentals that are expected to have an effect on the real effective exchange rate over the long run and medium term respectively. T_t is a vector of transitory factors affecting the REER in the short run while β1, β2 and τ are vectors of reduced-form coefficients. As usual, ε_t is a random error term.

Equation 1 implies that the real effective exchange rate is essentially explained in terms of a set of fundamental variables $Z_1$and Z_2, a set of variables that affect the exchange rate only in the short run, T, and the random error. It is common to distinguish between two types of misalignment, namely; current misalignment and total misalignment. According to Clark and MacDonald (1998), current misalignment is the difference between the actual REER and the REER given by the current values of the medium and long-term fundamentals q':

$$cm_t = q_t - q_t' = q_t - \beta_1' Z_{1t} - \beta_2' Z_{2t} = \tau' T_t + \varepsilon_t \quad (2)$$

Total misalignment on the other hand is defined as the difference between the actual real exchange rate and the real exchange rate given by the sustainable or long run values of the economic fundamentals, denoted as $\bar{Z}_{1t}$ and $\bar{Z}_{2t}$. Total misalignment is useful because the current values of the economic fundamentals may divert from sustainable or equilibrium levels. It is given as:

$$tm_t = q_t - \beta_1' \bar{Z}_{1t} - \beta_2' \bar{Z}_{2t} \quad (3)$$

Using equation (1) and (2), total misalignment can be rewritten as:

$$tm_t = \tau' T_t + \varepsilon_t + \beta_1'(Z_{1t} - \bar{Z}_{1t}) + \beta_2'(Z_{2t} - \bar{Z}_{2t}) \tag{4}$$

Equation 4 entails that the analysis of the total exchange rate misalignment takes into account the effect of transitory factors, random disturbances and the extent to which the economic fundamentals are away from their equilibrium values.

In practice, equation four is estimated within a cointegration and error correction framework. Essentially, the exchange rate assessment consists of three steps. Firstly, regression techniques are used to estimate a relationship between real effective exchange rate and a set of fundamentals. Secondly, the equilibrium real exchange rate is calculated using the long run or equilibrium levels of the fundamentals. Thirdly, the magnitude of the exchange rate misalignment is calculated directly as the difference between the actual real exchange rate and the equilibrium real exchange rate estimated in step two.

3.2. Model Specification and Variable Definition

There is extensive literature on the determinants of BEER based real exchange rates in developing countries (see Edwards (1989), Montiel (1999)). In practice, data availability constraints will naturally cause the choice of real exchange rate fundamentals to differ from one study to the other. In this study, the determinants of the REER are chosen based on IMF (2006), Lee et al. (2008) and Bussière et al. (2010). These studies give an extensive review of literature on medium to long run determinants of the equilibrium real exchange rate based on BEER approach.

The specification of the model to be estimated is as follows:

$$REER_t = \beta_1 + \beta_2 NFA_t + \beta_3 ToT_t + \beta_4 PRO_t + \beta_5 GCON_t + \beta_6 INTR_t + \beta_7 NER_t + \beta_9 IRD_t + \beta_{10} DEF_t + \beta_{11} DUM_1 + \beta_{12} DUM_2 + \beta_{13} DUM_3 + \varepsilon_t \tag{5}$$

where REER is real effective exchange rate, NFA is net foreign assets, ToT is terms of trade, PRO is productivity differential, GCON is government consumption, INTR is international reserves, NER is nominal exchange rate, IRD is interest rate differential, DEF is government deficit and DUM_1 is a dummy variable to account for the structural break in REER, DUM_2 is a dummy variable to account for the exchange rate volatility observed in 2015 and DUM_3 is dummy variable to account for the 2008 financial crisis.

Net Foreign Assets

Net foreign assets is taken to be the value of overseas assets owned by a nation, minus the value of its domestic assets that are owned by foreigners, adjusted for changes in valuation and exchange rates. Generally, debtor countries will require a more depreciated real exchange rate to generate the trade balances required to service their external liabilities but countries in creditors' position (or with high NFA) can maintain more appreciated currencies and run a trade deficit while still remaining solvent.

Terms of Trade

This variable is defined as the ratio of the export unit value index to the import unit value index. It is expected that higher commodity terms of trade will lead to an appreciation of the real exchange rate through real income or wealth effects. An improvement in the terms of trade leads to higher income and stronger demand for non-tradables, while deterioration in a country's terms of trade leads to weaker demand and currency depreciation (Levraks 2012).

Productivity Differential

This variable captures the supply side phenomenon known as the Balassa-Samuelson effect. Due to data limitations, this variable is proxied by gross national product divided by the population (Essien et al 2017; Zalduendo 2006). The Balassa-Samuelson stipulates that if productivity in the tradables sector grows faster than in the non-tradables sector, the resulting higher wages in the tradables sector will put upward pressure on wages in the non-tradables sector, resulting in a higher relative price of non-tradables or a real appreciation (IMF 2006).

Government Consumption

This variable is defined as the ratio of government expenditure to GDP. Generally, an increase in government expenditure which is directed more towards non-tradables will led to an increase in their price and thereby appreciate the real exchange rate.

International Reserves

These are reserves held at the central bank and therefore represents the capacity of the authorities to defend the currency (Aron et al, 1997). Generally, it is expected that an increase in the reserves will appreciate the real exchange rate while a decrease in reserves will lead to a depreciation.

Interest Rate Differential

This variable is computed as the difference between interest rate in Zambia and the United States. Ideally, an increase in the domestic interest rate is expected to attract capital flows from abroad which will lead to increased demand for the domestic currency and therefore an appreciation.

Nominal Exchange Rate

This is the official Kwacha/Dollar exchange rate defined as the number of Kwacha that can purchase one United States Dollar. An appreciation of the nominal exchange rate is expected to increase the real effective exchange rate.

Fiscal Deficit

This variable represents the fiscal policy stance of the government and it is computed as the ratio of the government budget deficit/surplus to GDP. Fiscal consolidation or an increase in the budget balance is likely to led to an increase in national savings, lower domestic demand and consequently a real depreciation. On the contrary, expansionary fiscal policy will worsen budget balances and cause an increase in domestic demand and hence a real appreciation.

4. Discussion of Results

In this section we present a discussion of the unit root test, structural break and cointegration tests that were conducted prior to estimating the model. We then proceed to discuss the estimated model and the computed real exchange rate misalignment. Post estimation diagnostic tests are also discussed.

4.1. Unit Root Tests

All the variables included in the model were subjected to the Augmented Dickey–Fuller unit root test to establish whether they are stationary or not. This is because theoretical literature and other empirical studies suggest that time series data are associated with the problem of non-stationarity. This problem, if not corrected for in OLS estimations, can lead to spurious regression results whereby no inference can be made since the standard statistical tests such as the "F" distribution and the student "t" distribution are invalid. A spurious relationship arises when the variables are related via a trend component and there is no economic long-run relationship. Table 2 and 3 give the results of the unit root tests at levels and at first difference.

Table 1: Results for Unit Root Tests for Variables at Levels.

Variable	ADF Statistics	Order of Integration
REER	-3.62	I(0)
NFA	-2.25	I(1)
TOT	0.66	I(1)
PRO	-3.62	I(0)
GCON	1.04	I(1)
INTR	-1.59	I(1)
NER	0.36	I(1)

Variable	ADF Statistics	Order of Integration
IRD	-0.62	I(1)
FISGDP	-2.56	I(1)

Notes: (i) McKinnon critical values are used for rejection of hypothesis of a unit root.
(ii) Critical values for ADF statistics are -3.5778, -2.9256 and -2.6005 at 1%, 5% and 10% Significance level respectively.

Table 2 reveals that except for REER and PRO, all the variables show the presence of unit roots at their levels thus confirming that they are non-stationary and integrated of order one I(1). Therefore, the first difference of the variables is taken and then tested for unit roots. The results are shown in the Table 3.

Table 2: Results for Unit Root Tests for Variables at First Difference.

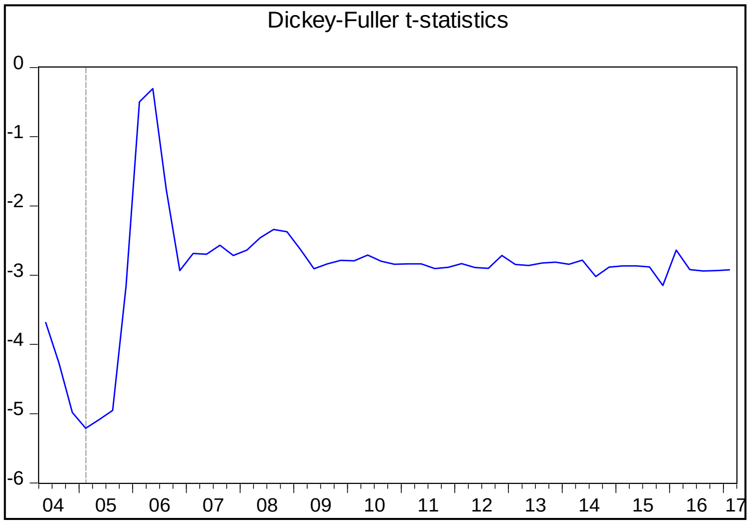
Variable	ADF Statistics	Order of Integration
NFA	-8.023	I(0)
TOT	-3.584	I(0)
PRO	-8.119	I(0)
GCON	-8.255	I(0)
INTR	-8.173	I(0)
NER	-5.723	I(0)
IRD	-6.138	I(0)
FISGDP	-3.818	I(0)

Notes: (i) McKinnon critical values are used for rejection of hypothesis of a unit root.
(ii) Critical values for ADF statistics are -3.5814, -2.9271 and -2.6013 at 1%, 5% and 10% level of significance respectively.

The results reveal that the variables become stationary after the first difference and hence they are integrated of order zero i.e. I(0).

Additionally, the dependent variable REER was subjected to a breakpoint unit root test to ascertain if they are any structural breaks in the series over the period of interest. The test results, with an F-statistic of -5.21 and probability 0.01, suggest that REER has a structural break at the first quarter of 2005. This implies that in modelling REER, we will have to account for the structural break this date. This is done by introducing a dummy variable which takes the value of 0 before 2005Q1 and 1 thereafter.

Figure 1: Structural Break in Real Effective Exchange Rate.



4.2. Co-integration Test

The non-stationarity of the variables necessitates a test for cointegration to establish if there is a long-run relationship among the variables. Engle and Granger (1987) argue that it is dangerous to do any kind of estimation prior to testing for cointegration. This study employs the Engel Granger two step test for cointegration, where one of this test step step involves estimating the regression using variables at their levels, and step two involves testing the saved residual for unit root. If the residual is stationary or integrated of order zero, then the variables are said to be cointegrated - implying that a long-run relationship exists.

Table 3: Cointegration Test Result

Variable	ADF Statistic	Order of Integration
Residual for the model	-6.93301*	I(0)

Notes: (i) *Significance at 1%

(ii) The McKinnon critical values are -3.56543, -2.91995, -2.59791 at 1%, 5% and 10% respectively

The test results for the model rejects the null hypothesis of no cointegration at one percent level of significance, hence there exists a cointegrating or long-run relationship between the variables. This result is important because it enables one to adopt an Error Correction Mechanism (ECM) as the appropriate estimation format for investigating the long-run causality. An ECM is used to combine the long-run, cointegrating relationship between the variables at levels and the short run relationship between the first differences of the variables. In other words, the error term from the cointegrating equation is treated as an equilibrium error and is used to tie the short-run behavior of the dependent variable to its long-run value. It has the advantage that all the variables in the estimated equation are stationary hence there is no problem with spurious correlation.

4.3. Regression Results

Long Run Model

The results for the long run model are presented in Table 4. They show that net foreign assets, productivity differential, international reserves, nominal exchange rate, interest differential and the fiscal balance are significant determinants of the real effective exchange rate in the long run. Particularly, the real effective exchange rate depreciates with an increase in net foreign assets, productivity differential, government consumption and interest rate differential. Conversely, the real effective exchange rate appreciates with an increase in nominal exchange rate, international reserves and fiscal deficit. Additionally, Dummy1 is negative and statistically significant suggesting that the structural break at date 2005Q1 had an impact on the real effective exchange rate. However, government consumption and terms of trade are not significant determinants of the real effective exchange rate. The coefficient signs are largely in line with Mkenda (2001). The long run model explains 93 percent of the variation in the real effective exchange rate. However, due to the non-stationarity of the variables, we estimate the error correction model that accounts for this problem.

Table 4: Results for the Long Run Model of REER

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.262	0.618	-5.281*	0.000
LOG(NFA)	-0.138	0.052	-2.674**	0.011
LOG(TOT)	-0.098	0.117	-0.841	0.405
LOG(PRO)	-0.524	0.095	-5.520*	0.000
LOG(INTR)	0.279	0.053	5.245*	0.000
LOG(NER)	0.670	0.071	9.497*	0.000
LOG(GCON)	-0.032	0.046	-0.708	0.483
LOG(IRD)	-0.038	0.022	-1.775***	0.083
FISGDP	0.337	0.199	1.695***	0.097
DUM1	-0.250	0.047	-5.336*	0.000
DUM2	0.020	0.024	0.813	0.421
DUMMY	-0.023	0.018	-1.297	0.202

R-squared	0.936	Akaike info criterion	-3.188
Adjusted R-squared	0.919	Schwarz criterion	-2.746
Durbin-Watson Stat	1.977	F-statistic	-3.188
		Prob(F-statistic)	0.000

Notes: The asterisk *, **, ***, indicates significance at the 1%, 5% and 10% levels respectively

Estimation of the Error Correction Model

The error correction model is estimated and tested for adequacy using various diagnostic tests. The specification of the ECM which adopts the general to specific approach by starting with an over-parameterised model in which two lags of each variable are included in the estimation. The lag length selection is in accordance with Mohtadi and Agarwal (2000). In the over-parameterised models, the explanatory variables include the lagged values of the dependent variable as well as the current and lagged values of the independent variables. However, in order to achieve parsimonious models or simply models that best fit the data, elimination of lagged values with most insignificant parameters was undertaken as informed by the Akaike Information Criteria (AIC).

Table 6 presents the results of the ECM. The results show that productivity differentia, international reserves, nominal exchange rate and interest differentials are significant determinants of the real effective exchange rate in the short run. Thus in the short run, the real effective exchange rate will appreciate with an increase in productivity and nominal interest rate and depreciate with an increase in interest differential. The ECM term is negative and statistically significant suggesting that about 42 percent of the error is corrected for in the first period.

Table 5: Results for the Error Correction Model for REER

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.063	0.034	-1.867	0.074
DLOGREER(-1)	0.119	0.143	0.836	0.411
DLOGREER(-2)	0.494	0.210	2.355**	0.027
DLOGNFA	0.031	0.064	0.481	0.635
DLOGNFA(-1)	0.080	0.059	1.351	0.189
DLOGNFA(-2)	0.048	0.064	0.740	0.466
DLOGTOT	-0.107	0.310	-0.347	0.732
DLOGTOT(-1)	0.238	0.263	0.907	0.373
DLOGPRO	3.976	1.679	2.369**	0.026
DLOGPRO(-1)	-6.723	2.828	-2.377**	0.025
DLOGPRO(-2)	3.695	1.827	2.022***	0.054
DLOGINTR	0.036	0.083	0.431	0.670
DLOGINTR(-1)	0.127	0.084	1.517	0.142
DLOGINTR(-2)	0.177	0.091	1.936***	0.064
DLOGNER	0.598	0.102	5.878*	0.000
DLOGNER(-2)	0.428	0.191	2.240**	0.034
DLOGCON	-0.006	0.043	-0.138	0.891
DLOGCON(-2)	-0.036	0.037	-0.974	0.339
DLOGIRD	-0.026	0.021	-1.239	0.227
DLOGIRD(-1)	-0.051	0.025	-2.049**	0.051
DFISGDP	0.006	0.216	0.030	0.976
DFISGDP(-1)	0.341	0.200	1.699	0.102
DUM1	0.035	0.027	1.319	0.199
ECM (-1)	-0.420	0.189	-2.225**	0.035
R-squared	0.878	Akaike info criterion		-3.585
Adjusted R-squared	0.766	Schwarz criterion		-2.658
Durbin-Watson stat	2.454	F-statistic		7.828
Sum squared resid	0.030	Prob(F-statistic)		0.000

Notes: The asterisk *, **, ***, indicates significance at the 1%, 5% and 10% levels respectively

4.4. Computed REER Misalignment Levels

As previously eluded to, the main objective of estimating a BEER based model of the real effective exchange rate was to be allow us to assess the extent of misalignment from the equilibrium rate. To estimate the misalignment, we use the Hodrick-Prescott (HP) filter to obtain long run or equilibrium estimates of the fundamental determinants. Once the HP filtered fundamentals are obtained, we can substitute them in our estimated models and obtain fitted values of the equilibrium exchange rate. Then the misalignment can be obtained as follows:

$$REER_{mis} = \left(\frac{Actual\ REER - Equilibrium\ REER}{Actual\ REER}\right) * 100$$

Table 6 and Figure 1 presents the computed percentages of misalignment for the real effective exchange rate measure while Figure 2 plots the real exchange rate against the estimated equilibrium exchange rate. The results show that the real exchange rate was overvalued and undervalued in a number of quarters over the period 2004Q1 to 2017Q2 but on average the exchange rate is overvalued by 1.574 percent. Over this period, we identify 30 quarters in which the exchange rate was overvalued and 24 quarters over which it was undervalued. One of the most notable episodes of misalignment was in the period 2005Q4 to 2008Q4 when the exchange rate was overvalued for 13 consecutive quarters and in the period 2010Q2 to 2012Q2 when it was undervalued for 9 consecutive quarters. Therefore, it appears that the market is more tolerant of an overvaluation.

Table 6: Real Effective Exchange Rate Misalignment

	Actual REER	Equilibrium REER	Misalignment (%)	Remark
2004Q1	2.196	2.159	-1.715	Undervaluation
2004Q2	2.227	2.134	-4.173	Undervaluation
2004Q3	2.227	2.110	-5.227	Undervaluation
2004Q4	2.188	2.087	-4.601	Undervaluation
2005Q1	2.046	2.064	0.898	Overvaluation
2005Q2	1.862	2.042	9.701	Overvaluation
2005Q3	1.712	1.573	-8.105	Undervaluation
2005Q4	1.370	1.557	13.650	Overvaluation
2006Q1	1.254	1.542	22.968	Overvaluation
2006Q2	1.281	1.527	19.242	Overvaluation
2006Q3	1.466	1.514	3.222	Overvaluation
2006Q4	1.469	1.501	2.185	Overvaluation
2007Q1	1.469	1.488	1.297	Overvaluation
2007Q2	1.397	1.476	5.688	Overvaluation
2007Q3	1.428	1.464	2.561	Overvaluation
2007Q4	1.390	1.453	4.582	Overvaluation
2008Q1	1.279	1.410	10.253	Overvaluation
2008Q2	1.197	1.400	16.964	Overvaluation
2008Q3	1.210	1.391	14.974	Overvaluation
2008Q4	1.317	1.383	5.013	Overvaluation
2009Q1	1.513	1.376	-9.106	Undervaluation
2009Q2	1.521	1.368	-10.033	Undervaluation
2009Q3	1.454	1.361	-6.402	Undervaluation

	Actual REER	Equilibrium REER	Misalignment (%)	Remark
2009Q4	1.421	1.354	-4.730	Undervaluation
2010Q1	1.344	1.346	0.150	Overvaluation
2010Q2	1.376	1.340	-2.672	Undervaluation
2010Q3	1.424	1.333	-6.412	Undervaluation
2010Q4	1.418	1.326	-6.448	Undervaluation
2011Q1	1.394	1.352	-3.049	Undervaluation
2011Q2	1.457	1.347	-7.604	Undervaluation
2011Q3	1.474	1.342	-8.966	Undervaluation
2011Q4	1.380	1.339	-3.007	Undervaluation
2012Q1	1.424	1.336	-6.179	Undervaluation
2012Q2	1.387	1.335	-3.731	Undervaluation
2012Q3	1.256	1.335	6.286	Overvaluation
2012Q4	1.313	1.337	1.787	Overvaluation
2013Q1	1.308	1.340	2.409	Overvaluation
2013Q2	1.267	1.344	6.122	Overvaluation
2013Q3	1.246	1.350	8.405	Overvaluation
2013Q4	1.263	1.357	7.474	Overvaluation
2014Q1	1.273	1.366	7.314	Overvaluation
2014Q2	1.416	1.375	-2.915	Undervaluation
2014Q3	1.312	1.413	7.687	Overvaluation
2014Q4	1.280	1.423	11.225	Overvaluation
2015Q1	1.314	1.434	9.172	Overvaluation
2015Q2	1.380	1.445	4.713	Overvaluation
2015Q3	1.543	1.455	-5.684	Undervaluation
2015Q4	1.789	1.465	-18.127	Undervaluation
2016Q1	1.558	1.445	-7.237	Undervaluation
2016Q2	1.470	1.452	-1.169	Undervaluation
2016Q3	1.469	1.459	-0.704	Undervaluation
2016Q4	1.402	1.465	4.499	Overvaluation
2017Q1	1.411	1.470	4.130	Overvaluation
2017Q2	1.360	1.474	8.403	Overvaluation
Average	**1.474**	**1.488**	**1.574**	**Overvaluation**

Figure 2: Actual REER vs Equilibrium REER

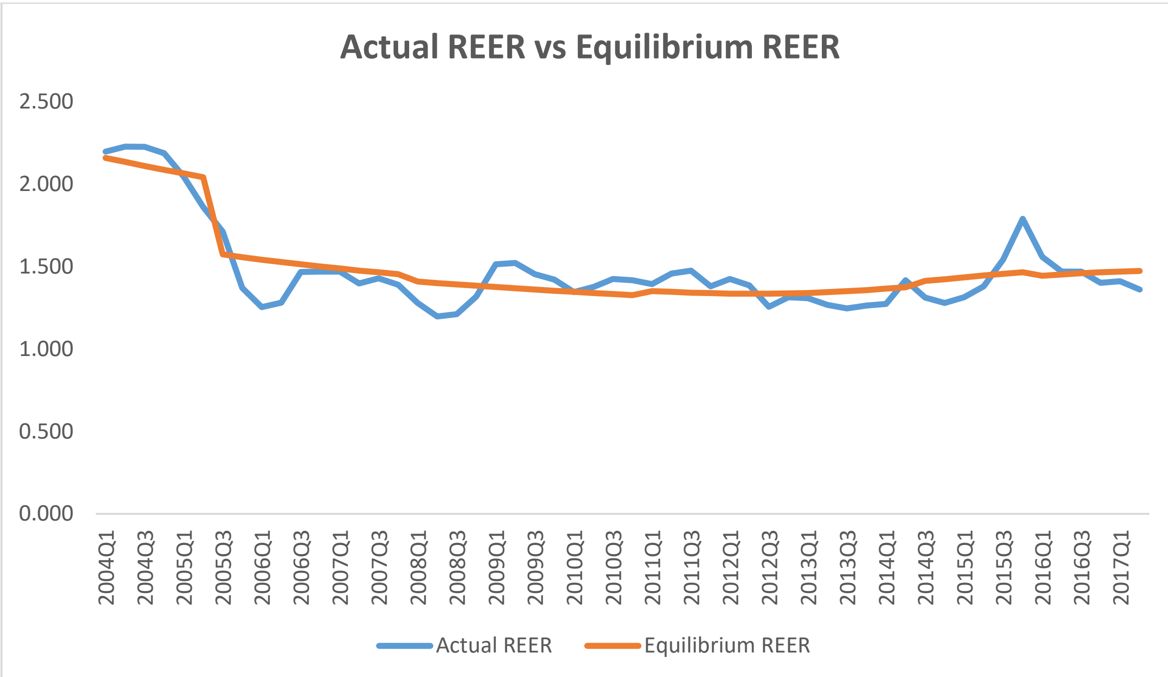
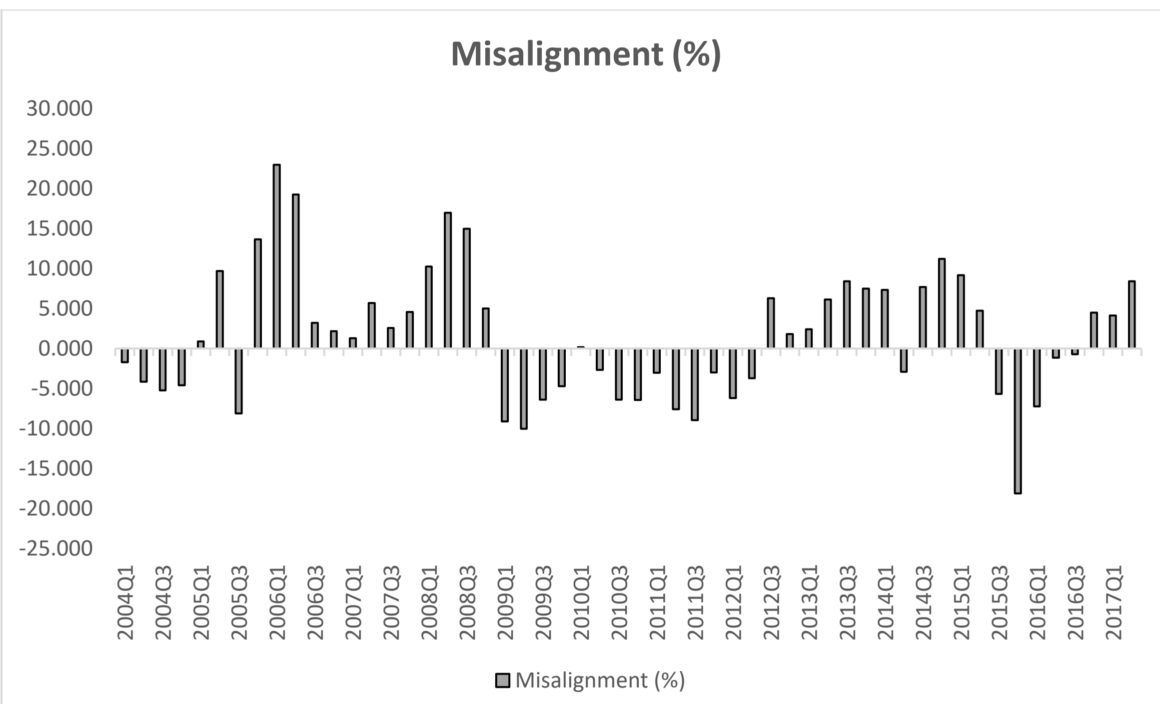


Figure 3: Real Effective Exchange Rate Misalignment



4.5. Models Evaluation and Diagnostic Tests

A number of tests were performed on the model before any interpretation of the empirical results was undertaken (see Appendix 1). This is done in order to discover the weakness of the models in terms of reliability and forecasting power as well as to determine if there is any misspecification in the model. Figures 1 gives the residual normality test while Table 1 gives the diagnostic tests. The tests show that the residuals were normally distributed and that there is no evidence of serial correlation among the variables. Additionally, the model is adequately specified and that there is no heteroscedasticity. Thus the model is reliable and can be used for forecasting.

5. Conclusion

The objective of this study was to estimate the equilibrium real exchange rate for Zambia and to compute the misalignment using quarterly data over the period 2004 to 2017. We applied the Behavioral Equilibrium Exchange Rate (BEER) approach to estimate the equilibrium exchange rate based on a set of fundamental in an error correction framework. Hence unit root and cointegration tests were done before estimating the model. The study found that there was a long run cointegrating relationship between the variables and this allowed for the adoption of the error correction model. The study also controlled for observed structural breaks in the dependent variable by using dummy variables.

The econometric results of the study show that net foreign assets, productivity differential, international reserves, nominal exchange rate, interest differential and the fiscal balance are significant determinants of the real effective exchange rate in the long run. The results also show that net foreign assets and terms of trade are significant determinants of the real effective exchange rate in the short run. Additionally, the dummy variable for the structural break in 2005Q1 is statistically significant.

After estimating the model, we proceeded to establish the equilibrium or long run levels of the fundamental determinants of the real exchange rate. This was achieved by using the HP filter to remove the cycles from the variables. This type of smoothing is standard in BEER literature. The HP filtered variables were then substituted into the model to obtain estimates of the equilibrium real exchange rate. The misalignment is then computed as the percentage difference between the actual real effective exchange rate and the estimated equilibrium exchange rate. The computations show that there have been many episodes of misalignment over the sample period with overvaluations accounting for the larger share.

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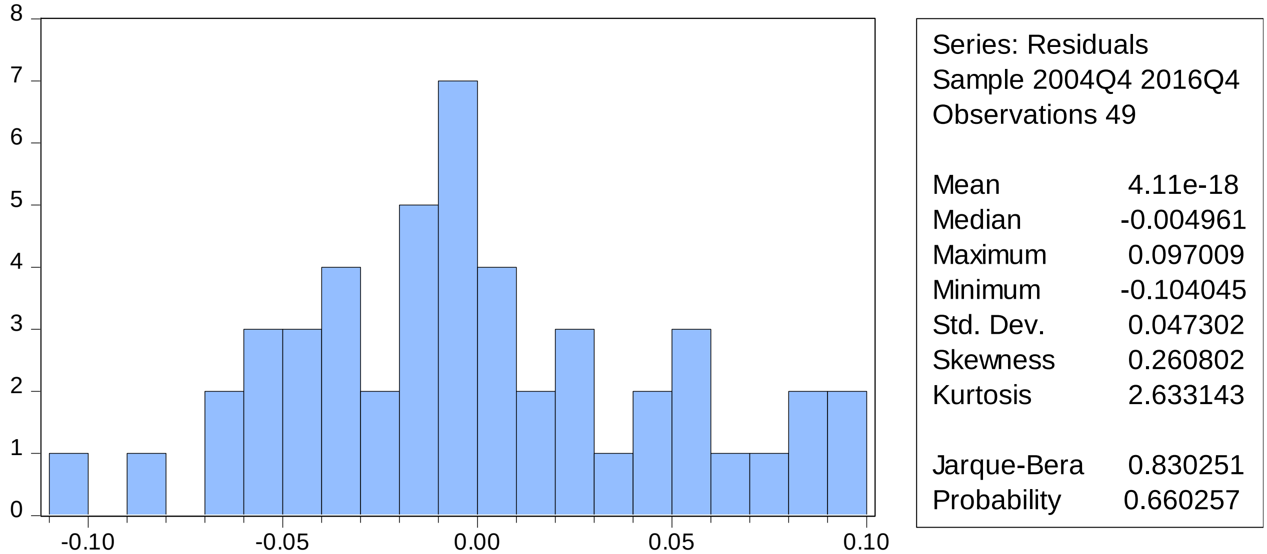
Appendix

Appendix Figure 1: Residual Normality Test



Appendix Table 1: Model Diagnostic Test Results

Test	
Breusch-Godfrey Serial Correlation LM Test:	
F-statistic	1.0356
Probability	0.3670
Ramsey RESET Test:	
F-statistic	0.4030
Probability	0.5300
White Heteroskedasticity Test:	
F-statistic	1.0585
Probability	0.4657
ARCH Test:	
F-statistic	0.7113
Probability	0.4034

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