



Central Bank of Kenya

An Assessment of Exchange Rate Misalignment in Kenya

October, 2019



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Abstract

Real exchange rate misalignment, which refers to a sustained significant deviation of the real exchange rate from its long run path consistent with economic fundamentals, can have implications on a country's economic performance. In particular, it can adversely affect trade and generate pressure for exchange rate volatility with negative consequences on macroeconomic stability and economic growth. Regular assessments of exchange rate misalignment are therefore necessary. This study analyses real exchange rate misalignment in Kenya over a more recent period, 2009Q1 to 2017Q4, using the Behavioral Equilibrium Exchange Rate (BEER) framework. Since the magnitude of misalignment could vary across methodologies owing to the set of built-in assumptions, this study also reports results based on alternative approaches for purposes of sensitivity analysis.

There are four key results from this study. First, the BEER results show that despite some variation in the magnitude of misalignment over time, this has declined and remained low in the period after 2013. The misalignment averaged 3.4 percent in the study period, but declined from an average of 4.1 percent in the period 2010-2013 to 2.6 percent in 2014 - 2017. This indicates that the country's real exchange rate has remained largely consistent with economic fundamentals. Second, the study finds that the Shilling was in fact, largely undervalued during most of the study period. Third, the relative stability in the nominal exchange rate observed during the period 2014-2017 related closely with stability in relative prices. Finally, our estimates of exchange rate misalignment based on the BEER were largely consistent with estimates using other alternative methodologies.

*This CBK Research Paper was prepared by a team led by Dr. Moses Kiptui. The author(s) thank the Governor, Dr. Patrick Njoroge, the Deputy Governor Mrs Sheila M'Mbijjewe, Members of the Monetary Policy Committee and an External reviewer for valuable comments and input received during preparation of this paper.

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Acronyms

ADF	Augmented Dickey Fuller
ARDL	Autoregressive Distributed Lag
BEER	Behavioral Equilibrium Exchange Rate
CA	Current Account
CPI	Consumer Price Index
EBA	External Balance Assessment
EBA-Lite	External Balance Assessment (Lite)
GDP	Gross Domestic Product
IMF	International Monetary Fund
MB	Macroeconomic Balance
NEER	Nominal Effective Exchange Rate
OLS	Ordinary Least Squares
PP	Phillips-Peron
PPP	Purchasing Power Parity
REER	Real Effective Exchange Rate
RER	Real Exchange Rate

1. Introduction

The growing integration of world economies has increased the transmission of shocks across countries and necessitated flexibility in the exchange rate for smooth adjustment to such shocks. The exchange rate plays an important role in the external adjustment process. Movements in the real exchange rate reflect fluctuations in relative prices with trading partners (Ajevskis et al, 2014).

Significant exchange rate movements raise concerns over consistency with economic fundamentals. Real exchange rate misalignment means that a nation's currency is either under or overvalued. It is under (over) valued when it is more depreciated (appreciated) than its 'ideal' value (Panday, 2014). The ideal is some measure of equilibrium, which is the level of the real exchange rate that is consistent with the goals of internal and external balance, which encompass high economic growth, low inflation and a sustainable current account balance. Misalignment of the real exchange rate can thus induce structural imbalances in the economy.

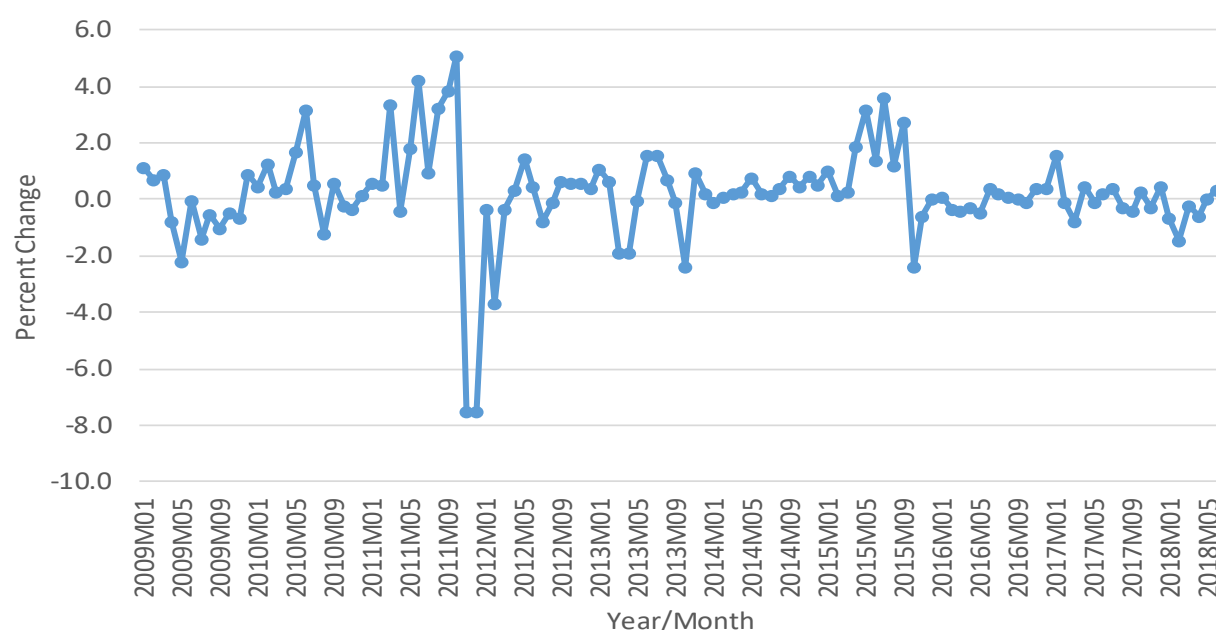
Prolonged and substantial exchange rate misalignment can create severe macroeconomic instabilities and the correction of external balance may require both exchange rate adjustment and demand management policies (Qayyum et al, 2005). Thus, with substantial capital mobility, substantial misalignment may be associated with very severe macroeconomic instability (Montiel, 2011). The evidence suggests that real exchange rate misalignment helps to explain the incidence of exchange rate crises and that such crises have substantial real output costs. Thus, large real exchange rate misalignments, or repeated episodes of small misalignments, are generally very costly to reverse.

From an external balance perspective, the exchange rate adjustment required to close the current account deficit depends to some extent on other policies being pursued. In this regard, other complementary policies could engender a reduction in the external gap. These include fiscal adjustment and increased savings. Others relate to policies which increase external competitiveness such as lowering the cost of doing business, improving labour skills and improving innovativeness. If the real exchange rate does not deviate significantly and persistently from its equilibrium level determined by economic fundamentals, relative prices remain close to equilibrium over time.

In the domestic front, the Kenya shilling–U.S. dollar nominal exchange rate has been largely stable since 2013 (Figure 1). It is noteworthy that real exchange rate movements reflect movements in nominal exchange rates and relative prices. Therefore, whenever large real exchange rate misalignment estimates are reported, it is bound to create contradictory perceptions on the exchange rate. Such perceptions can strongly affect market developments. Moreover, estimates pointing to overvalued positions would be interpreted as ensuing from policies detrimental to exporters, which ultimately make the country lose its competitive edge. It is therefore imperative that the level of exchange rate misalignment be ascertained to prevent distortionary effects. In this regard, this study addresses the following research questions:

- Is the real exchange rate misaligned? If misaligned, is the misalignment increasing or declining overtime?
- Are estimates of misalignment based on BEER approach comparable with estimates derived from other methodologies?

Figure 1: Monthly Percent Change in the Kenya shilling- U.S Dollar Exchange Rate¹



This study therefore assessed the level of misalignment of the real effective exchange rate (REER) of the Kenya Shilling, and afterwards undertook robustness checks using alternative methodologies over the period 2009 - 2017. Despite some variations over the magnitude of misalignment, it is evident that the level of misalignment has consistently declined overtime. Overall, misalignment of the Kenya shilling declined on average from 4.1 percent in 2010-2013 to 2.6 percent in 2014-2017. A number of observations are made: first, over 2014-2017, movements in relative prices remained low and displayed some consistency with the reduced change in the nominal exchange rate during this period implying that stability in nominal exchange rates relate closely with stability in prices. Second, the shilling was largely undervalued during the study period. Third, results from the BEER remained consistent with results from other alternative methodologies.

The rest of the paper is organized as follows: section 2 presents an overview of the literature, section 3 discusses the methodology applied in analysis, section 4 presents the empirical results, and section 5 concludes the study.

¹ The US dollar is the dominant trade and reserve currency as well as the currency in which Kenya's external debt is largely denominated.

2. Overview of Literature

2.1 Empirical Literature

Studies on exchange rate misalignment in Kenya are scanty. Mwega (2014) investigated whether the real exchange rate in Kenya was over-valued despite the adoption of a flexible exchange rate regime since the early 1990s. Cointegration analysis was applied relating the real exchange rate with key determinants such as terms of trade, openness, government expenditure ratio and economic growth and thus established a long-run relationship with the fundamentals. Using quarterly data covering the period 1995Q1- 2012Q1 and 1995Q4 as the base, the analysis showed that the real effective exchange rate had not significantly deviated from the estimated equilibrium rate in the study period. In 2012Q1, the results showed that the real exchange rate was only slightly misaligned, with an overvaluation of about 4.3 percent, with the nominal exchange rate being a principal factor driving the real exchange rate.

Kiptui, Wambua and Maturu (2013) examined real exchange rate misalignment in Kenya using data over the period 1998 – 2012. The study applied the popular Behavioral Equilibrium Exchange rate (BEER) approach and showed that the equilibrium real exchange rate was closely aligned to its long run equilibrium level except for instances when misalignment occurred due to major economic shocks such as the global financial crisis (2007-2010)² and the Euro zone debt crisis (2009-2012)³. Misalignment generally remained within a 10 percent band, particularly between 1999-2010. This study also identified some overvaluation of the exchange rate in 2012 and sizable undervaluation in 2011 as in the Mwega paper. An earlier study by Musyoki et al (2012) examined real exchange rate (RER) misalignment in Kenya by using Johansen Cointegration and error correction technique based on single equation and Vector Autoregressive (VAR) specification. It was found that the actual RER was more often above its equilibrium value for the study period of June 1993 – December 2009.

Kargbo (2006) focused on purchasing power parity and real exchange rate behaviour in Africa. This study conducted a detailed empirical investigation to ascertain whether or not there is empirical support for long-run PPP in African countries, Kenya included. The study applied Johansen's cointegration method to annual data of 40 countries covering the 1958–2003 period. The study lends overwhelming support for long-run PPP in Africa, and the author asserts that PPP is a reliable guide for exchange rate determination and exchange rate policy reform in African countries.

More recently however, the IMF introduced and implemented the External Balance Assessment (EBA) approach (in 2012)⁴ and its variant, the EBA-Lite (in 2016)⁵. The EBA-lite estimates nevertheless deviated widely from previous measures of exchange rate misalignment for Kenya (see IMF, 2014; IMF, 2018a). The question is whether these estimates can be corroborated using traditional measurement approaches.

² Lee et al (2017) notes that the global financial crisis started in the second half of 2007.

³ Thompson (2015) asserts that the Greek crisis started in October 2009, deteriorated in March-May 2010, leading to bailout in March-April 2012; also noted that Euro-zone crisis deepened in 2011.

⁴ The methodology is described in the papers: Phillips, S. et al (2013). The External Balance Assessment (EBA) Methodology. IMF Working Paper WP/13/272, and "IMF (2013). External Balance Assessment (EBA) Methodology: Technical Background" (<http://www.imf.org/external/pubs/ft/wp/2013/wp13272.pdf>; <https://www.imf.org/external/np/res/eba/pdf/080913.pdf>).

⁵ Described in "IMF (2016): Methodological Note On EBA-Lite" (https://www.imf.org/~media/Websites/IMF/imported-full-text-pdf/external/np/pp/eng/2016/_020516.ashx)

2.2 Methodological Review

To be able to gauge the level of real exchange rate misalignment, we need to derive an estimate of the equilibrium real exchange rate, the rate that is consistent with internal and external balance of the economy which mainly encompasses high economic growth, low levels of inflation and current account sustainability.

A number of methodologies exist in the literature for the analysis of the equilibrium real exchange rate. Most of these methodologies have strengths and weaknesses. The Purchasing Power Parity (PPP) approach is anchored on the test of cointegration of the nominal exchange rate with relative prices (the ratio of domestic to foreign prices). Though it is a common starting point to infer about the equilibrium exchange rate there is a strong consensus in the literature that PPP is not an appropriate measure for the developing economies (Hinkle & Montiel, 1999). This is because countries in a catch-up process may experience a trend appreciation of the real exchange rate, for which simple version of PPP theory cannot account. The PPP approach relies on simplifying assumptions relating to matching consumption baskets and tastes across countries necessary for realizing comparable price measures or CPI. PPP also assumes that price differences across countries is arbitrated away, an assumption often negated by high transaction costs. The PPP, however, has advantages as it is simple and demands less data. The exchange rate misalignment is easily calculated as deviations from the level implied by PPP.

On the other hand, current account (CA)-based measures also exist: The elasticities approach and Macroeconomic Balance (MB) approach. The elasticities approach, in particular the Krugman (1989) equation is derived mathematically from the dynamics of the current account balance. In this case, the exchange rate is considered to adjust according to imbalance in the current account, to equilibrate exports and imports of goods and services. The adjustment mechanism to attain internal and external balance in the economy relies on the elasticity of exchange rates with respect to export and import volumes. This approach is however considered inflexible since it is equation-based and hence has limited scope for manipulation to include other relevant variables.

The Macroeconomic Balance (MB) approach is an offshoot of the Fundamental Equilibrium Exchange Rate (FEER). The FEER which was developed by Williamson (1994), has been widely used by the IMF to estimate directly the sustainable level of current account deficits based on the saving and investment balance⁶. The exchange rate is considered to adjust accordingly to equilibrate savings and investment in the medium term when the economy has achieved its potential level of output. The determination of the equilibrium and underlying current accounts is therefore based on well specified structural models. Moreover, this approach relies on coefficients generated by regressions in past panel studies and therefore can be applied to countries which have limited data. However, uncertainties often emerge due to the unreliability of these panel regression coefficients and price and income elasticity estimates produced by past studies.

The IMF has since introduced a new framework for assessing external sector adjustments-the EBA and EBA-Lite approaches which borrow from the above methodologies. The new IMF approach however deviates

⁶ FEER defines the equilibrium exchange rate as the rate that satisfies simultaneously internal and external balance, i.e. current account sustainability or current account which matches long-term capital inflows. To determine the size of long-term capital flows however, the FEER approach relies on normative judgment.

significantly by enhancing the normative component and by focusing on three gaps (structural, policy and exchange rate gaps) as opposed to previous preoccupation with the exchange rate misalignment in country assessments. Moreover, the equilibrium REER and Current account in the EBA approach are estimated with some relatively new determinants; the range of determinants has increased and variable definitions have changed too. EBA separates fundamentals into policy variables, non-policy fundamentals, and cyclical variables.

An examination of previous EBA estimates for developed and emerging countries indicates that these estimates face substantial uncertainties / differences (see IMF, 2014; IMF, 2018b). IMF External Sector Reports provide three types of estimates: REER-based, current account (CA)-based and External Sustainability (ES)-based. It has been argued that EBA assessments on the REER should be taken very cautiously when current account to GDP ratios are high (Ekinci & Kilinc, 2013). IMF (2012) notes that the CA-based measure has limitations, most apparent in analyzing countries with very important or dominant special sectors, such as large oil exporters and relatively small economies that are financial centers. For some countries, this approach yields very large regression residuals, and thus lead to high exchange rate misalignment⁷. The REER-based EBA measure of exchange rate misalignment on the other hand suffers from reduced reliability in countries with large productivity differentials or other large structural changes, as well as those with short data spans. While summing up the 2018 External Sector Report, the IMF Board suggested that future presentation of EBA estimates be presented in ranges or intervals (instead of point estimation) for all countries as was done for some countries in the 2018 report; to reflect the uncertainty of the estimates⁸. Due to the level of normative structure embodied in the EBA framework, it is considered less appealing for empirical analysis.

Unlike the PPP which assumes that the equilibrium REER is constant over time, the Behavioral Equilibrium Exchange Rate (BEER) allows the equilibrium REER to vary and respond to the economy's fundamentals and macroeconomic conditions. The popularity of the BEER is brought about by the observation that they can explain well the real exchange rate movements even when estimated in a reduced form (Maeso-Fernandez, Osbat, & Schnatz, 2002). The BEER does not approach the equilibrium real exchange rate from the point of view of internal and external equilibria, but rather from the point of view of consistency with relevant fundamentals. Thus, misalignment can arise from "bubble" factors, transitory policy shocks, slow adjustment of predetermined variables and/or inappropriate policies. In comparison with other approaches, the BEER approach is considered very flexible as it is a general exchange rate modelling approach. It is widely applied empirically due to its attractive features including the rigorous statistical nature of estimation it affords and the limited scope for normative elements. Hence, the BEER approach is considered more suitable for developing economies.

⁷ This is discussed in pages 35-36 in the IMF Working Paper: "The External Balance Assessment (EBA) Methodology", IMF Working Paper WP/13/272" (<http://www.imf.org/external/pubs/ft/wp/2013/wp13272.pdf>)

⁸ 2018 External Sector Report- The Acting Chair's Summing Up 2018 External Sector Report, Executive Board Meeting 18/66 (<https://www.imf.org/~media/Files/Publications/ESR/2018/esrsummingup.ashx>)

3. Methodology

3.1 Estimation methods

While many empirical approaches to modelling equilibrium real effective exchange rates have been documented in the literature, the analysis in this paper adopts the Behavioural Equilibrium Exchange Rates (BEER) put forth by MacDonald (1997) and Clark and MacDonald (1998) which links the real exchange rate to a set of macroeconomic variables through a single equation setting. The BEER estimation entails three steps:

1. Estimating an equation relating REER and its economic fundamentals;
2. Deriving sustainable values of the fundamentals using an appropriate filter and applying the derived values of the fundamentals and the model coefficients to compute equilibrium REER;
3. Computing the REER misalignment as the difference between the actual and the equilibrium REER.

According to the BEER approach, the total exchange rate misalignment at any point in time has three components: the extent to which the economic fundamentals deviate from their sustainable values, the effects of transitory factors, and random disturbances.

The possible fundamentals which influence the REER are discussed in IMF (2006), Lee et al (2008), Bussière et al (2010) and Chinn and Prasad (2003). The equilibrium REER is thus specified as a linear function of the following set of fundamental variables in line with Toulaboe (2017):

$$REER_t^* = f(\overset{-}{NFA}, \overset{-}{PDIF}, \overset{+/-}{INVR}, \overset{+/-}{TOT}, \overset{+}{OPEN}, \overset{+/-}{GCR}) \quad (1)$$

where $REER_t^*$ is the equilibrium REER, NFA is net foreign assets, PDIF is relative productivity in the tradable goods sector relative to the non-tradable sector, INVR is the ratio of domestic investment to GDP, TOT is terms of trade, OPEN stands for openness to trade and GCR is government spending on tradable and non-tradable goods. The expected signs of the coefficients are shown below the variables.

Net foreign assets (NFA)

The inclusion of the outstanding stock of foreign assets as a determinant of the real exchange rate follows portfolio-balance considerations. Increases in net foreign assets represent increases in wealth and should be associated with an appreciated real exchange rate (Adler & Grisse, 2017). Equivalently, net creditor countries will eventually need to run trade deficits to satisfy their intertemporal budget constraints, which is facilitated by a real exchange rate appreciation.

Productivity differential (PDIF)

Since technological innovations are more likely to originate from the tradables sector, it results in productivity differential between the tradables and the non-tradables sectors. As productivity increases in the tradables sector, pressure will mount on wages in this sector to rise. Such an increase in wages in the tradables sector will lead to consequent demands for wage increases in the non-tradable sector. Thus, an increase in relative prices in the non-tradables sector will result in real appreciation of the currency. For emerging countries, the real exchange rate tends to appreciate overtime as productivity in the tradables sector increases faster than in developed countries whereas productivity differences in non-tradables sector across countries is considered negligible. Thus, an increase in productivity differential (PDIF) is expected to appreciate the REER.

Domestic investment (INVR)

The impact of domestic investment (as a ratio of GDP) on the REER is ambiguous. The impact depends on the composition of the investment spending. For instance, if domestic investment is biased toward local goods (non-tradables), RER appreciation may result. Moreover, higher investment ratio is expected to raise productivity leading to real appreciation of currency.

Commodity terms of trade (TOT)

A deterioration in the terms of trade and the imposition of an import tariff have somewhat similar effects. Both shocks imply a higher domestic price of importables and a reduction of the quantity demanded of these goods. Overall, a lasting deterioration of the terms of trade of a country should result in a depreciation of the real exchange rate of that country. The expected sign of the variable is however, a priori ambiguous because it relies on income and substitution effects and whether the terms of trade shock is due to a change in export prices or import prices. An improvement in the terms of trade increases real national income (income effect) and a rise in the demand for both tradable and non-tradable goods, leading to upward pressure on the relative price of non-tradables - a real appreciation. If, however it causes substitution effects on the supply and demand sides then it exerts a depreciating effect on the RER. The net effect is ambiguous.

Trade openness (OPEN)

The openness to trade (OPEN) is proxied by the ratio of the sum of exports and imports to GDP. Trade liberalization policy increases the openness of an economy to international trade and is therefore expected to depreciate the RER.

Government spending to GDP ratio (GCR)

An increase in government spending, largely due to an increase in the share of non-tradable goods, will raise the price level of non-tradables relative to that of tradables and appreciate the REER. According to Frenkel and Mussa (1988), a fiscal tightening causes a permanent increase in the net foreign assets position of a country and, consequently, an appreciation of its equilibrium exchange rate in the longer term, provided that the fiscal consolidation is considered to have a permanent character. If, however, the increase in government spending is biased toward the tradable sector it will cause the REER to depreciate. Nevertheless, Government spending is often thought to be biased towards nontraded goods, generally associated with a real appreciation. The effect of government spending on the REER is therefore ambiguous, depending on the composition of government spending.

Further to equation 1, an Auto Regressive Distributed Lag (ARDL) model is specified as:

$$\begin{aligned}
\Delta \text{LOG}(\text{REER}) = & \theta_0 + \theta_1 \text{LOG}(\text{NFA})_{t-1} + \theta_2 \text{LOG}(\text{PDIF})_{t-1} + \theta_3 \text{LOG}(\text{INVR})_{t-1} \\
& + \theta_4 \text{LOG}(\text{TOT})_{t-1} + \theta_5 \text{LOG}(\text{OPEN})_{t-1} + \theta_6 \text{LOG}(\text{GCR})_{t-1} \\
& + \theta_7 \text{LOG}(\text{REER})_{t-1} + \sum_{i=1}^{i=h} \lambda_{1i} \Delta \text{LOG}(\text{REER})_{t-i} + \sum_{i=0}^{i=k} \lambda_{2i} \Delta \text{LOG}(\text{NFA})_{t-i} \\
& + \sum_{\substack{i=0 \\ i=q}}^{i=m} \lambda_{3i} \Delta \text{LOG}(\text{PDIF})_{t-i} + \sum_{i=0}^{i=n} \lambda_{4i} \Delta \text{LOG}(\text{INVR})_{t-i} + \sum_{i=0}^{i=p} \lambda_{5i} \Delta \text{LOG}(\text{TOT})_{t-i} \\
& + \sum_{\substack{i=0 \\ i=r}} \lambda_{6i} \Delta \text{LOG}(\text{OPEN})_{t-i} \\
& + \sum_{i=0} \lambda_{7i} \Delta \text{LOG}(\text{GCR})_{t-i}
\end{aligned} \tag{2}$$

The bounds F-test is applied and entails testing the null hypothesis $\theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = \theta_6 = \theta_7 = 0$ against the alternative hypothesis $\theta_1 \neq 0, \theta_2 \neq 0, \theta_3 \neq 0, \theta_4 \neq 0, \theta_5 \neq 0, \theta_6 \neq 0, \theta_7 \neq 0$. The long run relationship between the variables is validated if the computed F-statistic exceeds the upper bound critical value i.e. if the null hypothesis is rejected.

If a long run relationship is established, a regression model is fitted and the coefficients derived from the regression are used to estimate a long run trajectory of the REER using medium term values of the determinants, hence providing an estimate of the equilibrium REER. Misalignment is the deviation of the actual real exchange rate from its equilibrium.

3.2 Data, Sources, and Description

3.2.1 Measurement of the Real Effective Exchange Rate

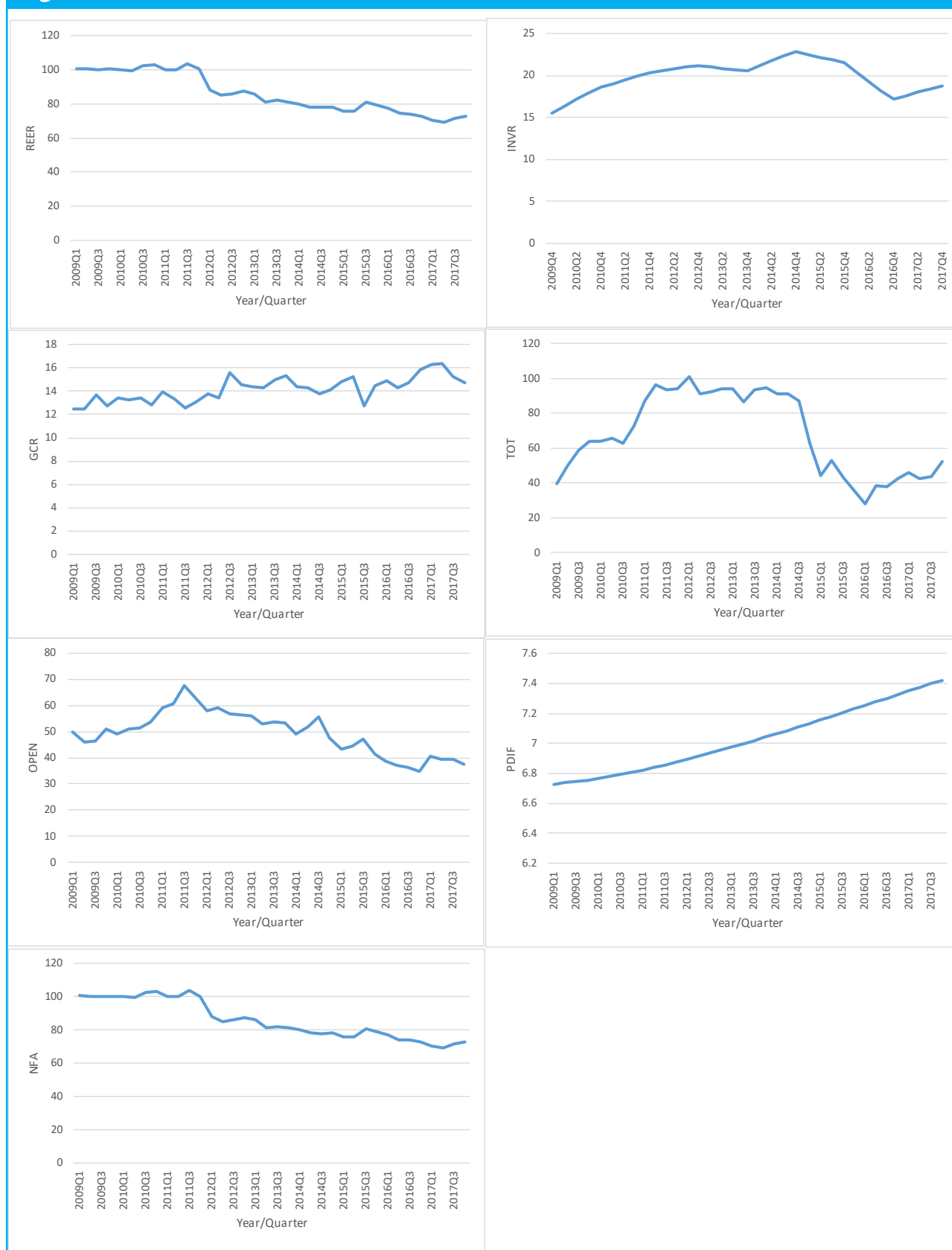
The real effective exchange rate is obtained by getting the weighted average of the product of the nominal bilateral exchange rate index and foreign prices and then dividing the product by domestic prices. CPI-based price indices are used in this study. The detailed description of the procedure adopted in this study is presented in Appendix B.

3.2.2 Sources and Description of Data

Data is obtained from Central Bank of Kenya (CBK), Kenya National Bureau of Statistics (KNBS), IMF's World Economic Outlook (WEO), Bruegel and World Bank. The study used both quarterly and annual data (for some selected analyses). Table 1 describes the data used in BEER estimation and their respective sources, while Figure 2 depicts the variables' trends overtime.

Table 1: Variable definitions			
Variable	Abbreviation	Description	Source
Real Effective Exchange Rate	REER	As described in section 4.1	CBK
Net foreign assets	NFA	net foreign assets as a ratio of nominal GDP	CBK
Productivity differential	PDIF	ratio of Kenya to U.S. values of GDP per person employed (constant 2011 PPP \$)	WB/WEO
Domestic investment	INVR	ratio of domestic investment to GDP	KNBS
Commodity terms of trade	TOT	proxied by price of Crude Oil Price (Murban) deflated by U.S. CPI	IFS/CBK
Trade openness	OPEN	Exports plus imports as ratio of nominal GDP	CBK/IFS
Government spending to GDP ratio	GCR	recurrent / consumption government expenditure as ratio of nominal GDP	KNBS

Figure 2: Variables Trends



4. Empirical Analysis

4.1 The Real Effective Exchange Rate (REER)

This study adopts currency weights in the computation of the real effective exchange rate (REER). The process starts with determination of trade weights for major trading partners and using these weights to determine currency weights based on the most commonly used currency in transactions. The trade weights are computed using trade data over 2014-2016 (average exports plus imports with a trading partner as proportion of total trade, over a three- year period). Currency weights are then determined. The trade weights and subsequent currency weights are provided in tables 2 and 3.

Table 2: Trade weights

Country	Trade Weight
China	0.15
India	0.12
Japan	0.04
South Africa	0.03
Tanzania	0.02
Uganda	0.03
UK	0.04
Euro Area	0.16
USA	0.09
Middle East	0.12
Pakistan	0.02
Other African Countries	0.11
Other	0.09

Source: Computed using CBK database

Table 3: Currency weights

Currency	Currency weight
Chinese Yuan	0.15
Indian Rupee	0.12
Japanese Yen	0.04
South African Rand	0.03
Tanzania Shilling	0.02
Uganda Shilling	0.03
UK pound	0.04
Euro	0.16
US dollar	0.41
Of which	
Middle East	0.12
Pakistan	0.02
Other African countries	0.11
Other	0.09

Different measures of the real effective exchange rate are then compared: the REER designed in this study, the IMF REER based on trade weights of 20 trading partners and, the Bruegel measure based on 41 trading partners (Figure 3). The NEER derived in this study is also compared with Bruegel’s measure of NEER (Figure 4). The measures are fairly close despite the differences in the number of trading partners considered and the weighting schemes adopted.

Figure 3: This Study’s REER compared with IMF and Bruegel REER

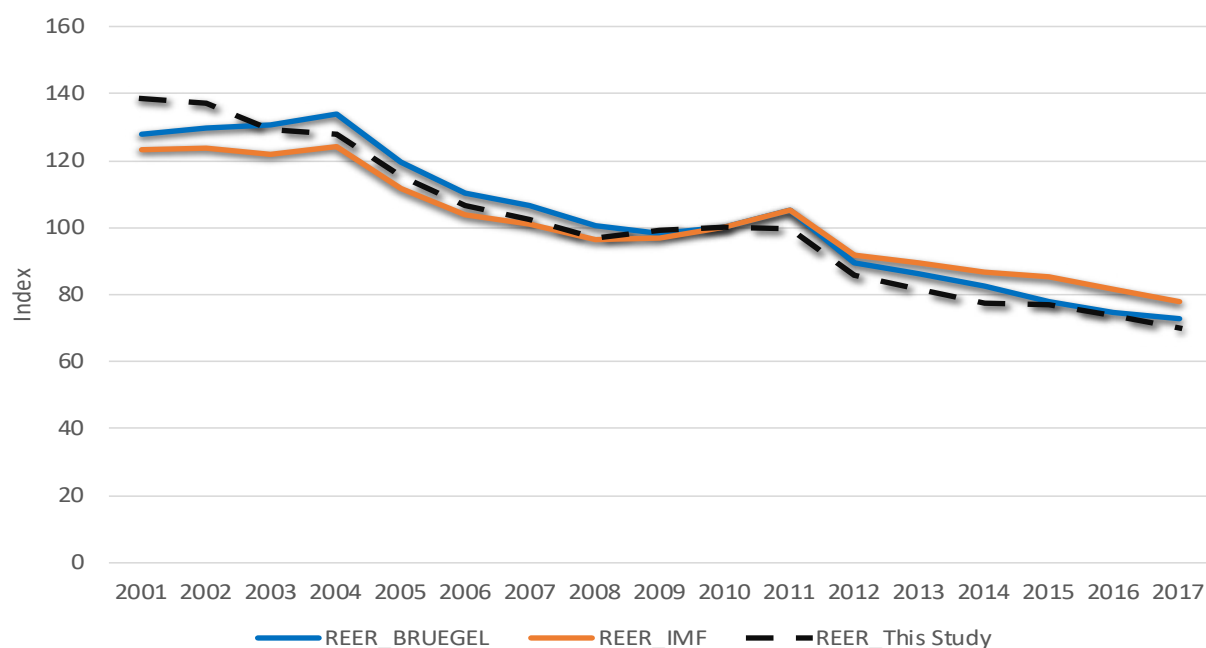
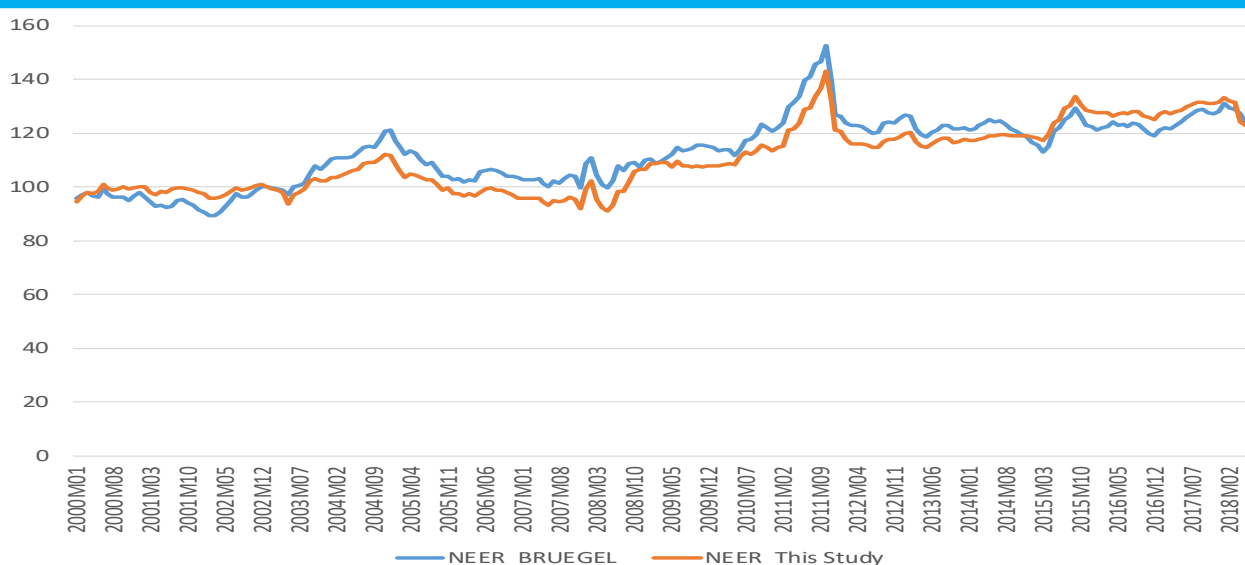


Figure 4: This Study’s NEER compared with Bruegel NEER



⁹ <http://bruegel.org/publications/datasets/real-effectiveexchange-rates-for-178-countries-a-new-database/>

4.2 Behavioral Equilibrium Exchange Rates (BEER)

The starting point is the determination of the order of integration of the variables' series. The unit root tests with application of Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests indicate that two variables are stationary at levels but the rest are integrated of order one (Table 4). Hence, ARDL methodology is the appropriate framework for estimation. The estimation results indicate that except for net foreign assets, all the included variables had significant long-run effects (Table 5). The net foreign assets variable was, however, significant in the short run (see Table 7). The coefficient signs are generally as expected with net foreign assets, productivity differential, investment and government consumption exerting appreciating effects on REER while terms of trade and openness exert depreciating effects.

The F-bounds test and the ECM t-test both confirm the existence of a long run relationship between the real exchange rate and its fundamentals (Table 6). The bounds F-test is significant at 5 percent. The error correction term is highly significant and indicates that 60.7 percent of the REER deviation from equilibrium is corrected within one quarter.

The estimated model coefficients are as given in table 5. These coefficients are then applied in consequent computations. Thus, the equilibrium real exchange rate is determined by removing the cyclical component from the fundamentals and using the estimated long run coefficients to estimate values of the real exchange rate consistent with the medium-term trends of the fundamentals¹⁰. Figure 7 compares the actual REER and the equilibrium REER as derived using the BEER methodology. Misalignment is the gap between the actual exchange rate and the equilibrium exchange rate. The diagnostic tests are as shown in Table 7 and figures 5 and 6. The model shows that errors are normally distributed without serial correlation and heteroskedasticity. The stability of the model and estimated coefficients is confirmed by Ramsey RESET test, Cumulative Sum (CUSUM) and Cumulative Sum of Squares (CUSUMSQ).

Misalignment of the real exchange rate is as shown in figure 8. It is indicated that, except for the 2011-episode, exchange rate misalignment remained below 5 percent over most of the sample period. It is indicated that over most of the study period, the shilling was undervalued.

As shown in Figure 9a, during the 2014-2016 period, a negative association between the current account balance and the REER was experienced as depreciation occurred in the backdrop of sizeable deterioration of the current account balance. It is also indicated that the third quarter of 2011, during which misalignment was highest, is associated with greater openness and coincides with the Eurozone debt crisis, thus indicating the effect of external shocks during this time (Figure 9c). Further, it is shown that the current account movements strongly correlate in a negative manner with fluctuations in government spending, suggesting a close link between fiscal policy and external balance (Figures 9b and 9d).

¹⁰ The Hodrick-Prescott filter is applied to remove the cyclical component.

Table 4: Unit Root Tests

	ADF	Prob	PP	Prob
At Level				
LOG(REER)	-0.662	0.849	-0.926	0.775
LOG(NFA)	-3.505	0.014	-3.081	0.037
LOG(PDIF)	-0.999	0.750	-0.907	0.781
LOG(INVR)	-2.523	0.120	-2.340	0.166
LOG(TOT)	-1.421	0.562	-1.630	0.457
LOG(OPEN)	-0.798	0.808	-0.815	0.803
LOG(GCR)	-2.994	0.045	-2.886	0.057
First Difference				
LOG(REER)	-8.564	0.000	-10.376	0.000
LOG(PDIF)	-6.90	0.000	-2.787	0.006
LOG(INVR)	-5.774	0.001	-2.233	0.027
LOG(TOT)	-4.442	-0.001	-4.432	-0.027
LOG(OPEN)	-4.796	0.001	-5.930	0.000

Note: Variable names are defined in appendix A (3)

Table 5: ARDL Regression Results (BEER)

Dependent Variable: LOG(REER)			
Variable	Coefficient	t-Statistic	Prob.
LOG(NFA)	-0.142	-0.791	0.437
LOG(PDIF)	-2.042***	-3.982	0.001
LOG(INVR)	-0.343***	-3.466	0.002
LOG(TOT)	-0.104*	-1.976	0.061
LOG(OPEN)	0.445***	2.998	0.007
LOG(GCR)	-0.323*	-1.861	0.076
C	8.836***	7.895	0.000

Note: *, **, and *** imply significance at 10 percent, 5 percent and 1 percent respectively

Table 6: Bounds F-Test

Test statistic			Critical Values(n=30, k= 6)	
	Value	Significance level	I(0)	I(1)
F-statistic	4.527**			
k	6	10 percent	2.334	2.334
		5 percent	2.794	2.794
Actual Sample Size	33	1 percent	3.976	3.976

Note: *, **, and *** imply significance at 10 percent, 5 percent and 1 percent respectively

Table 7: Error Correction Model

Dependable Variable: DLog (REER)

Variable	Coefficient	t.Statistic	Prob.
DLOG(REER(-1))	0.428***	3.854	0.001
DLOG(NFA)	-0.069	-1.418	0.170
DLOG(NFA(-1))	0.160***	3.163	0.005
ECT(-1)	-0.607	-6.909	0.000
Diagnostics		t.Statistic	
Adjusted R-squared		0.628	
Jarque-Bera		0.407 (prob. = 0.816)	
Breusch-Godfrey Serial Correlation LM Test:		Chi_Square(2)= 1.564 (prob.= 0.458)	
Heteroskedasticity Test: Breusch-Pagan-Godfrey		Chi-Square (10) = 9.577 (prob. = 0.478)	
Ramsey RESET Test		F(1,21)= 2.285 (prob.= 0.146)	

Note: *, **, and *** imply significance at 10 percent, 5 percent and 1 percent, respectively

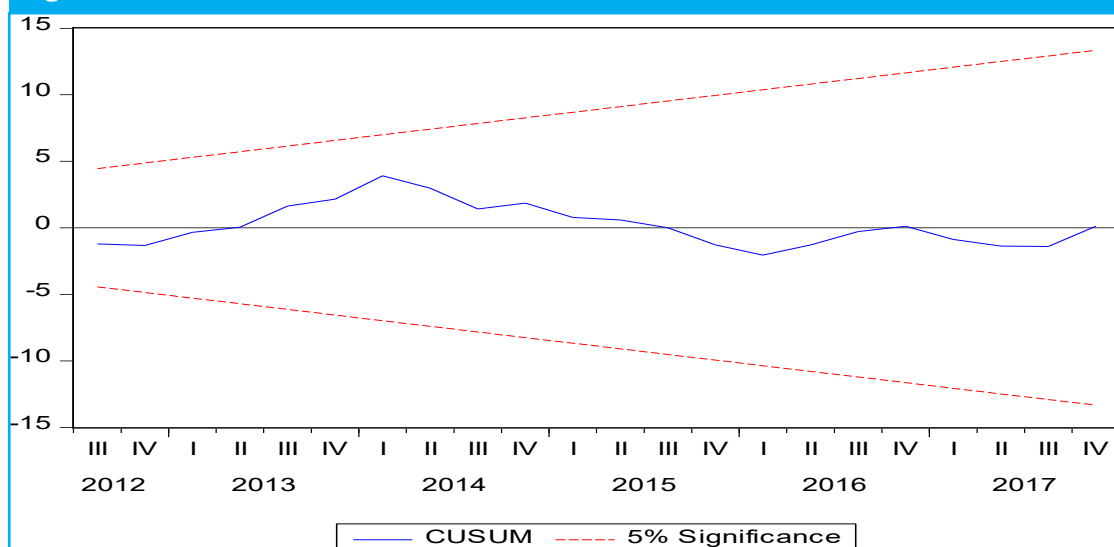
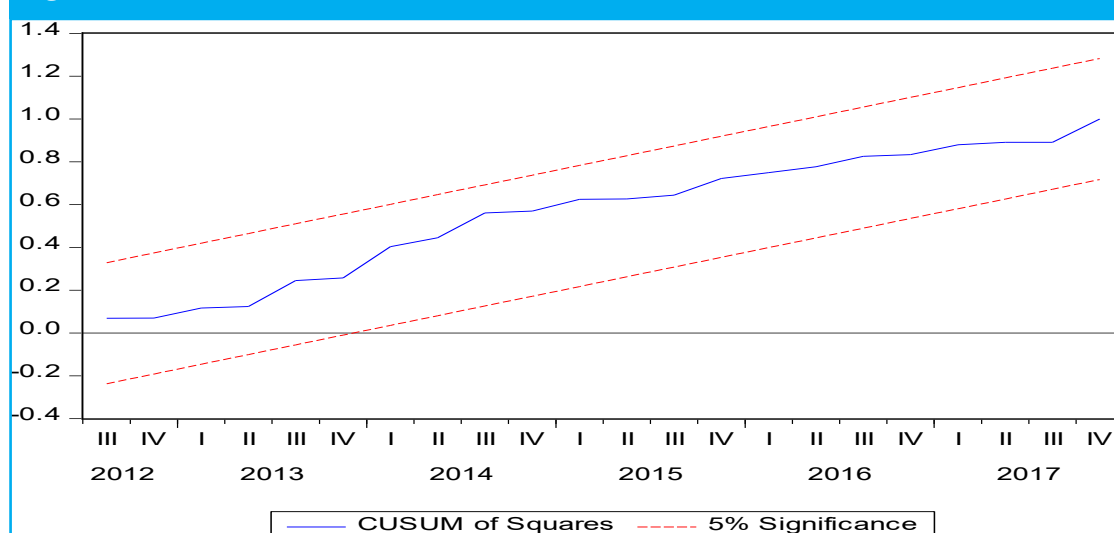
Figure 5: CUSUM**Figure 6: CUSUM of Squares**

Figure 7: Actual REER versus equilibrium values

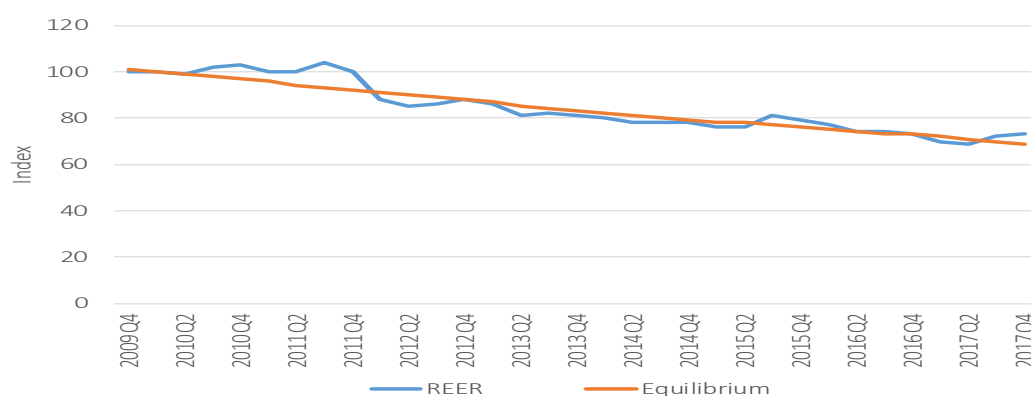


Figure 8: Misalignment – BEER

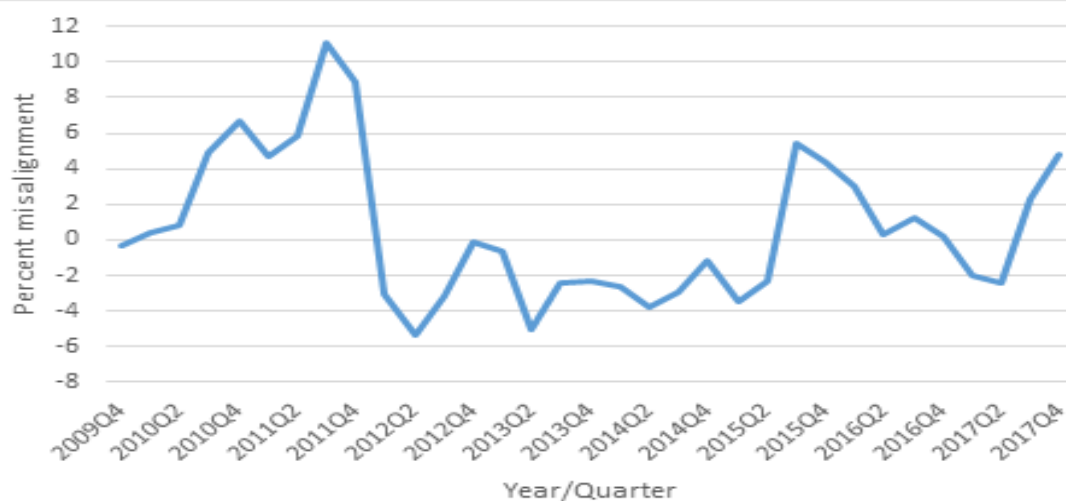


Figure 9a: Percent changes in CAB and REER

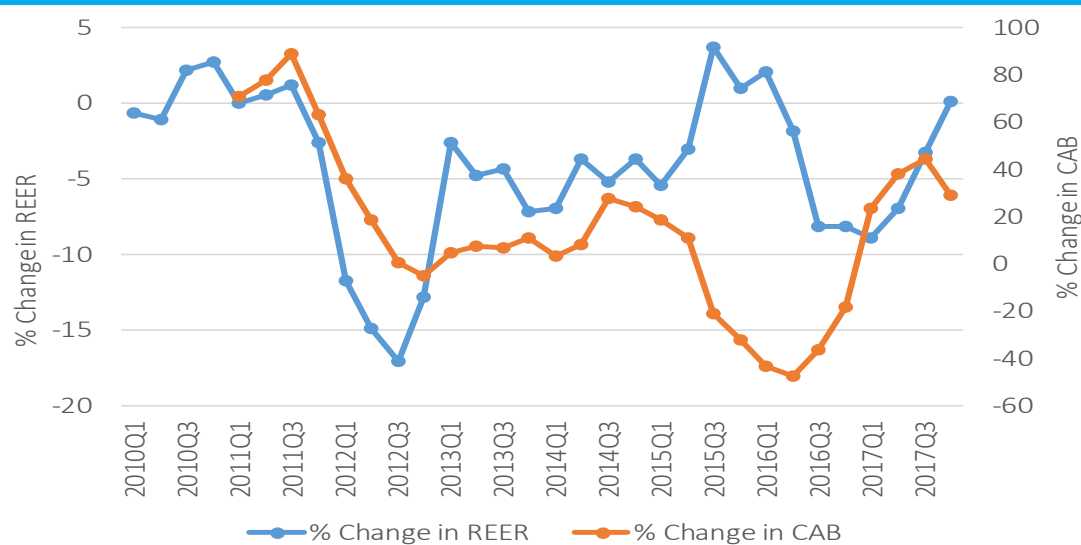


Figure 9b: Per cent changes in total and recurrent government expenditure (Govt. Exp)

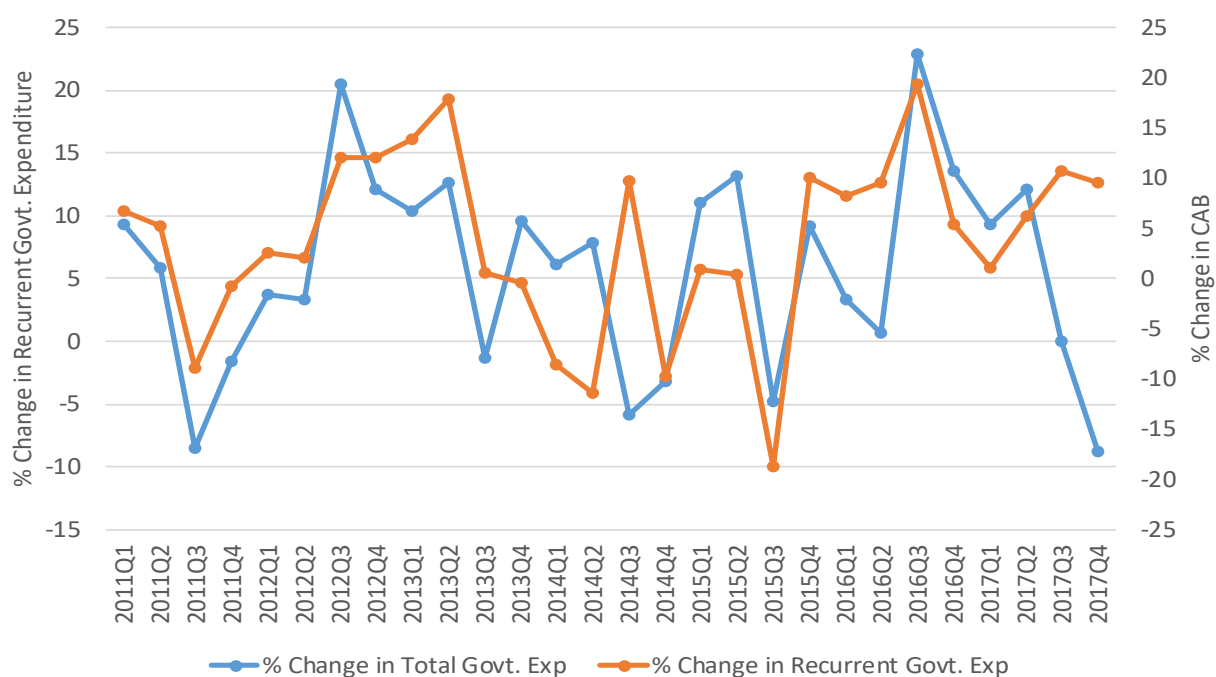


Figure 9c: Openness (exports + imports as % of GDP)

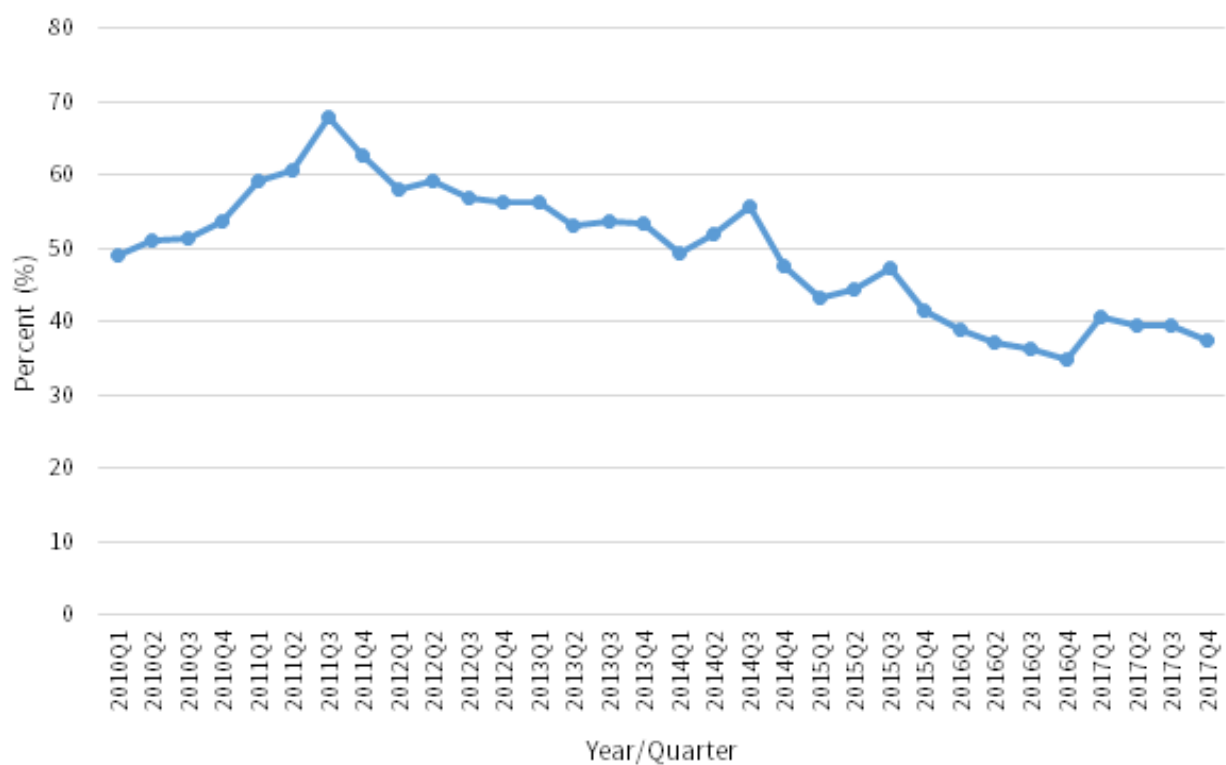
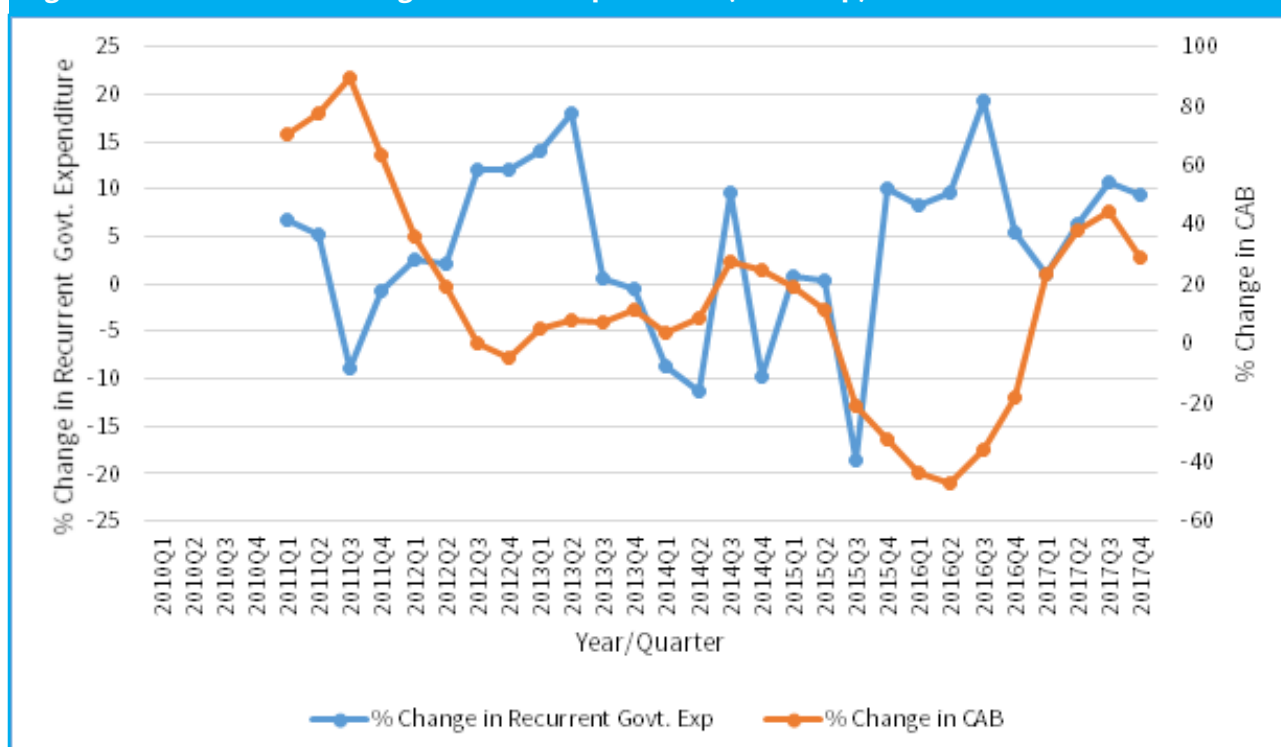


Figure 9d: CAB and recurrent government expenditure (Govt. Exp)



4.3 Robustness

Other approaches are adopted in this study so as to assess the consistency of exchange rate misalignment estimates and to enhance the credibility of the BEER results. Therefore, for robustness check, the estimation approaches adopted include purchasing power parity, trade elasticities and macroeconomic balance approaches.

The detailed description of each of these approaches is presented in Appendix A.

4.3.1 Purchasing Power Parity (PPP)

The Purchasing Power Parity (PPP) approach is anchored on the test of stationarity of the relationship between the nominal exchange rate and relative prices. The exchange rate misalignment is calculated as deviations from the level implied by PPP. PPP hypothesis states that the real exchange rate is constant in the long run. Thus, the long-run equilibrium real exchange rate can be written as (see Montiel, 2011):

$$REER^* = REER_0 \quad (3)$$

where $REER_0$ is a constant and represents the long run real exchange rate, and the actual real exchange rate $REER$ is given by:

$$\text{Log}(REER) = \text{log}(REER_0) + \epsilon \quad (4)$$

$$\text{So that } \text{Log}(REER) - \text{log}(REER_0) = \epsilon \quad (5)$$

where ϵ is a mean-reverting stationary random variable.

Since $\text{log}(REER_0)$ is a constant, stationarity of ϵ requires that the actual real exchange rate be stationary and/or that the NEER be cointegrated with relative prices i.e. the equation $\tilde{s}_t = \alpha + \beta(p_t - p_t^*)_t$ as described in appendix A must have a co integrating vector if PPP is to hold.

In the literature, misalignment is taken to be the deviation from PPP, measured either as deviations from the long run relationship or deviations from $REER_0$ subjectively selected by the researcher with judgement guided by picking a base year/ period when REER is deemed to be at equilibrium, typically interpreted as choosing a year with a reasonable or normal current account (or resource) deficit for the country concerned. Thus, the actual REER in the base period represents the estimate of the equilibrium rate. Also equilibrium REER may be estimated using a long-term trend value. The equilibrium exchange rate could be considered as evolving along a deterministic or stochastic trend. Misalignment is then measured as the difference between the actual REER in the current year and its equilibrium value in the base year or along the long-run trend.

Figure 10 shows the close association between fluctuations in the nominal effective exchange rate and relative prices. As shown in table 8, the variation in relative prices (RELP) was much lower in the period 2013M01 to

2018M06 relative to 2001M01 to 2012M12. It can be argued that the reduced movements in relative prices during this period is consistent with observed reduced changes in the nominal effective exchange rate. The analysis is extended to confirm existence of cointegration between exchange rate and relative prices given the strong co-movement between the two series. In fact, the correlation between relative prices and NEER over 2001M01 to 2012M12 is found to be 0.6. Unit root tests using both Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) methods are performed on NEER and relative prices (Table 9). The findings confirm that the variables are integrated of order one, paving the way for cointegration tests to be performed. We use quarterly data from 2009Q1 to 2018Q2, and Fully Modified Least squares with optimal lags selected using Akaike Information Criteria to determine the existence of a long run relationship between the variables. The Engle-Granger (1987) cointegration test confirms a long run relationship between NEER and relative prices. The null hypothesis is that the series are not cointegrated. This is rejected at 10 percent level of significance using the Engle-granger tau statistic and at 1 percent level with the z-statistic. The long run coefficients are reported in table 10.

Further, we carried out analysis using monthly data of the REER over the period 2000M1 to 2018M6. The analysis involved checking if REER series is stationary. It is found that REER is indeed trend stationary. This necessitated that we regress REER on a constant and a trend term. The regression results are reported in Table 11. The residual series derived from this regression is plotted in Figure 11. Using our results in Table 11, the misalignment of the actual REER from trend is computed and shown graphically in Figure 12. This misalignment is compared with BEER-based misalignment. Figure 12 shows that misalignment has declined overtime. Except for 2011Q3 and Q4, exchange rate misalignment remained below 5 percent over most of the period. It is shown that the shilling was largely undervalued during the study period. In addition, the misalignment derived from the PPP methodology closely tracks BEER misalignment, with correlation between the two series being high at 0.94.

Figure 10: Relationship between changes in nominal effective exchange rate and relative prices

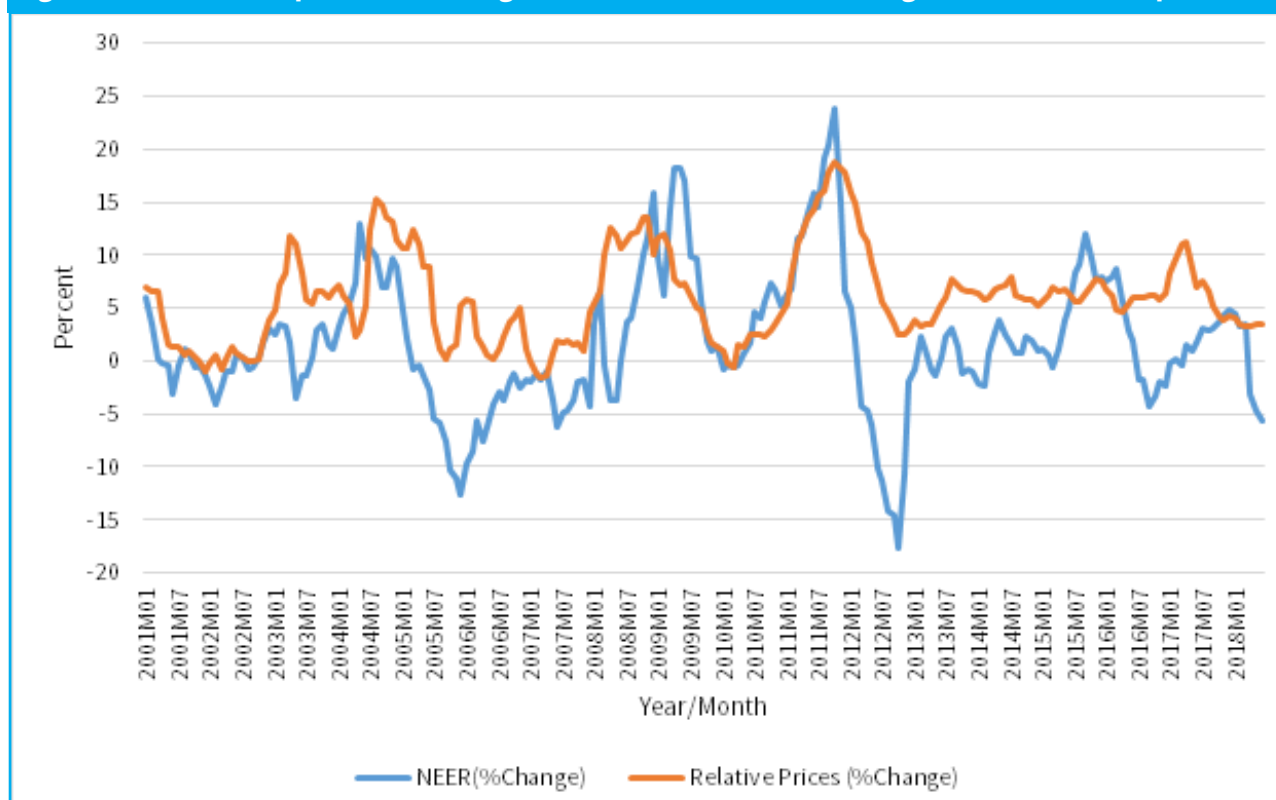


Table 8: Standard Deviation and Coefficient of Variation of NEER and Relative Prices

	NEER		Relative Prices (RELP)	
period	Std Deviation	Coefficient of Variation	Std Deviation	Coefficient of Variation
2001M01-2012M12	7.41	4.36	5.13	0.87
2013M01-2018M06	3.66	1.89	1.68	0.28

Table 9: Unit Root Tests

		ADF t-Statistic	Prob	PP t-Statistic	Prob
NEER ($\tilde{s}_t$)	At Level	-2.259	0.190	-1.992	0.289
	First Difference	-4.745	0.000	-4.128	0.003
RELP	At Level	0.05	0.957	-0.044	0.948
	First Difference	-4.042	0.003	-3.937	0.005

Table 10: Long-run coefficients

Dependent Variable: LOG(NEER)			
Variable	Coefficient	t-Statistic	Prob.
LOG(Relative Prices)	0.263	5.085	0.000
C	4.523	379.792	0.000
R-squared	0.57		
Adjusted R-squared	0.56		
Cointegration Test - Engle-Granger			
		Value	Prob.
Engle-Granger tau-statistic		-3.315	0.075
Engle-Granger z-statistic		-26.906	0.003

Table 11: Trend Stationary REER

Dependent Variable: REER			
Variable	Coefficient	t-Statistic	Prob.
C	111.383	178.125	0.000
@TREND	-0.263	-63.863	0.000
R-squared	0.949		
Adjusted R-squared	0.949		
Unit Root Tests on Residual			
Augmented Dickey Fuller Test	t=-4.076 (Prob=0.001)		
Phillips-Perron Test	Adj.t-stats= -3.512 (Prob=0.009)		

Figure 11: Regression residual series

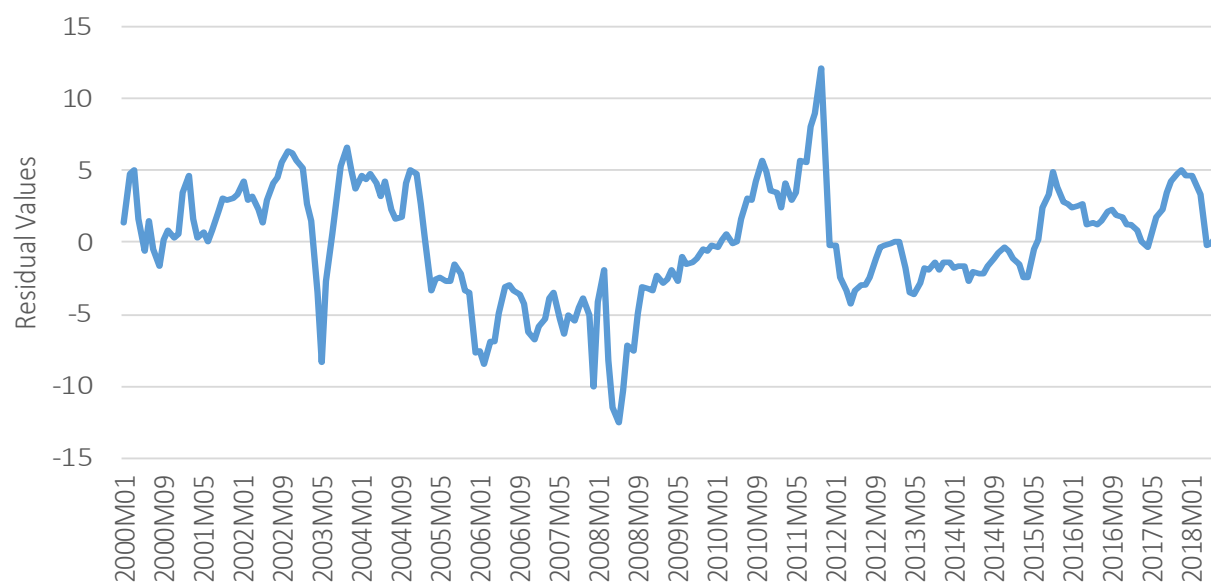
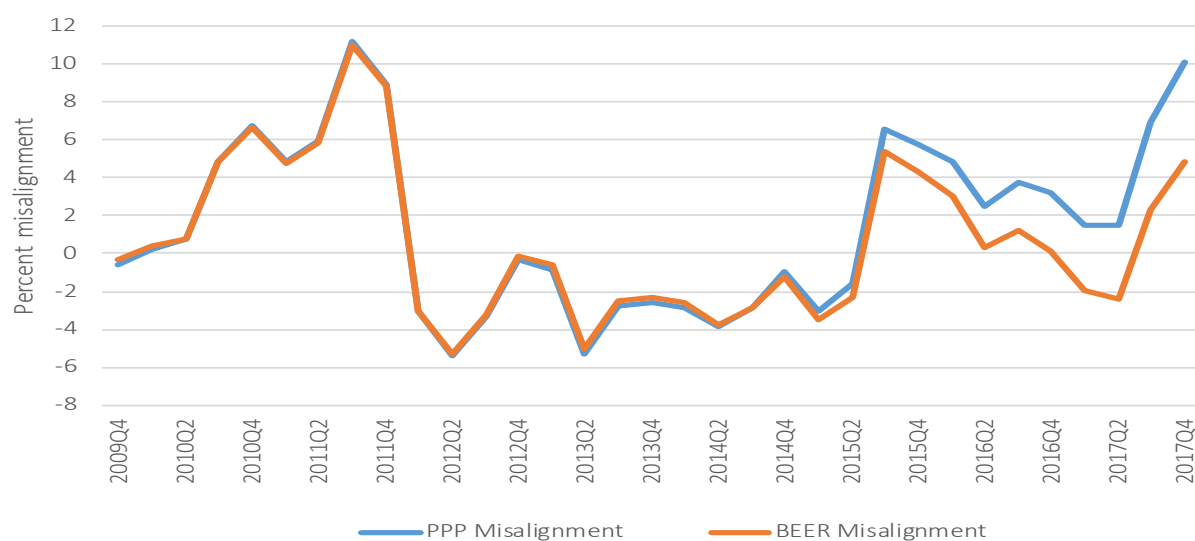


Figure 12: PPP Misalignment compared with BEER Misalignment



4.3.2 Trade Elasticities Approach

The trade elasticities methodology is focused on finding an exchange rate adjustment which will bridge the gap between exports and imports of goods and services. This involves estimation of price and income elasticities of exports and imports and using these estimates together with growth rates of domestic and foreign incomes to find the exchange rate adjustment that would equilibrate exports and imports of goods and services.

We follow the approach in Kumah (2011), using equation 16 in Appendix A to compute the required real exchange rate adjustment. The estimation of exports and import demand models is done using Autoregressive Distributed Lag (ARDL) models. The unit root tests in table 12 indicate that all the variables are integrated of order one and that they become stationary after first differencing. We apply Pesaran, Shin and Smith (2001) bounds test in analysis to determine the existence of a long run relationship between the variables. The F – bounds test and the ECM t-statistic test proposed by Banerjee et al (1998) both support the existence of long run relationships for the export and import models. The resulting long run coefficients are as reported in tables 13 and 14. The change in exchange rates dictated by the estimated elasticities is used to evaluate the level of misalignment. The calculations entail substituting the estimated coefficients into equation 16. Table 13 shows that a 1 percent increase in relative prices reduces exports by 1.4 percent. Also, a 1 percent increase in foreign economic activity (incomes) raises exports by 6.4 percent in the long-run.

In similar vein, table 14 indicates that a 1 percent increase in relative prices has insignificant effect on imports suggesting that imports are price inelastic in nature. The low price elasticity of imports implies that the exchange rate is less effective as a tool for current account adjustment and thus cannot be considered the only panacea for external imbalances. A 1 percent increase in domestic incomes, however, has significant effects on imports, increasing imports by 4.7 percent.

Misalignment of the exchange rate is shown in figure 13, indicating that except for a few episodes it generally remained within a band of 5 percent over the period. The shilling was undervalued (above 5 percent) in real terms in 2011Q1, 2012Q1 and 2013Q2, and was overvalued (above 5 percent) in 2012Q4 and 2015Q3. For most of the study period, however, the shilling was largely undervalued.

Table 12: Unit Root Tests

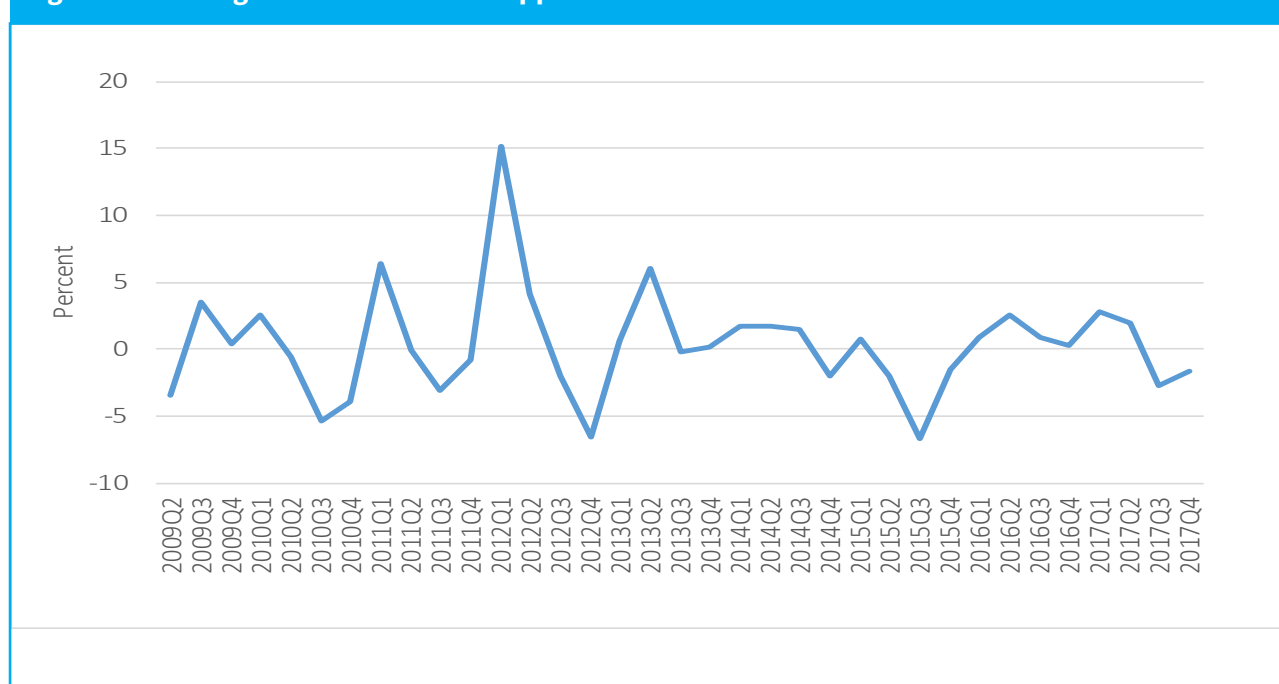
	ADF t-statistic	Prob.	PP t-statistic	Prob.
Variable At Level				
log(X)	-1.305	0.621	-1.538	0.507
LOG(DEF)	-0.180	0.932	-0.011	0.951
LOG(RELPX)	-0.217	0.931	0.650	0.990
log(y [*])	-0.223	0.930	-0.459	0.893
log(M)	-1.601	0.475	-1.786	0.384
LOG(RELPM)	-0.217	0.931	0.650	0.990
Log(y)	-1.802	0.373	-2.019	0.278
First Difference				
log(X)	-7.083	0.000	-7.179	0.000
LOG(DEF)	-7.695	0.000	-8.354	0.000
LOG(RELPX)	-8.117	0.000	-10.376	0.000
log(y [*])	-5.034	0.000	-4.681	0.000
log(M)	-10.080	0.000	-10.080	0.000
LOG(RELPM)	-8.117	0.000	-10.376	0.000
log(y)	-4.697	0.001	-4.825	0.000

Table 13: ARDL Long- run Coefficients (Elasticities) of Estimated Exports model

Dependent variable: LOG (Exports of goods and services)				
Variable	Coefficient	t-Statistic	Prob.	
LOG(GDP Deflator)	-1.029	-3.929	0.002***	
LOG(Relative Prices(x))	-1.368	-3.362	0.006***	
LOG(weighted Foreign real GDP index)	6.414	6.138	0.000***	
C	-18.701	-3.226	0.007***	
F-Bounds Test: k=3				
Actual Sample Size: n=32				
computed F-statistic	5.588**			
			Critical Values (n=30, k=3)	
	Significance Level		I(0)	I(1)
	10 percent		2.676	3.586
	5 percent		3.272	4.306
	1 percent		4.614	5.966
		Significance Level	Critical values(n=25,k=3)	
ECM coefficient & t-statistic	-0.885 (t= -6.104)***	10 percent	3.46	
		5 percent	3.91	
		1 percent	4.92	
*, **, and *** imply significance at 10 percent, 5 percent and 1 percent respectively.				

Table 14: ARDL Long- run Coefficients (Elasticities) of Estimated Import model

Dependent variable: LOG (Imports of goods and services)				
Variable	Coefficient	t.Statistic	Prob.	
LOG(GDP Deflator)	-3.061	-5.837	0.000***	
LOG(Relative Prices(m)	-0.228	-0.727	0.475	
LOG(Domestic Real GDP)	4.691	7.209	0.000***	
C	-35.700	-4.912	0.000***	
F-Bounds Test: k=3 Actual Sample Size: n=33 computed F-statistic	4.001*			
	Significance Level		Critical Values for finite Sample: n=35	
			I(0)	I(1)
	10 percent		2.618	3.532
	5 percent		3.164	4.194
	1 percent		4.428	5.816
ECM coefficient & t-statistic	-0.743			
	(t=-4.85)**	Significance Level	Critical values(n=25,k=3)	
		10 percent	3.46	
		5 percent	3.91	
		1 percent	4.92	
*, **, and *** imply significance at 10 percent, 5 percent and 1 percent respectively.				

Figure 13: Misalignment - Elasticities Approach


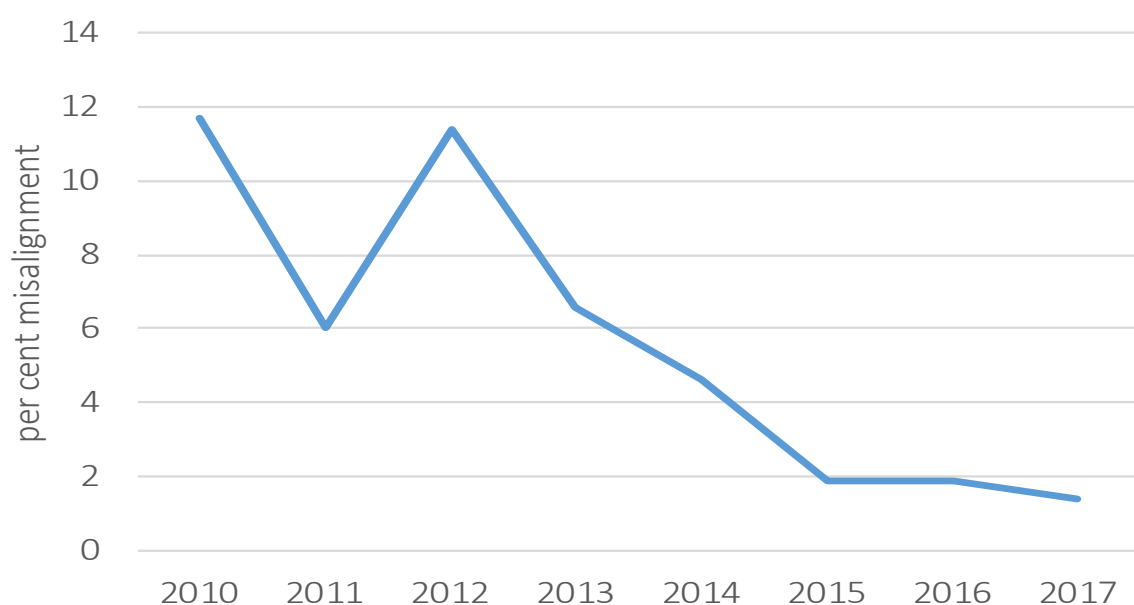
4.3.3 Macroeconomic Balance Approach estimates

This approach involves the computation of underlying current account (UCA) which is basically the adjustment of the headline current account with respect to changes in exchange rates and cyclical movements in domestic and foreign economic activity to derive medium term estimates of the current account. This is followed by the computation of the equilibrium current account (CA norm), using the coefficients in Lee et al (2008).

The exchange rate adjustment (to bridge the gap between underlying current account and the equilibrium current account) is then computed. This procedure is further discussed in Appendix C.

Following this procedure, it is possible to determine the extent of misalignment of the REER as given in figure 14.

Figure 14: Exchange rate misalignment- Macroeconomic Balance approach



4.3.4 A Comparison of Misalignment Estimates from the different Approaches

To effectively compare the magnitude of misalignment overtime, we split the sample period into two equal periods: 2010-2013 and 2014-2017. The analysis shows that overtime, the level of misalignment has consistently declined (Table 15). The level of misalignment based on the BEER approach declined from 4.1 percent in 2010-2013 to 2.6 percent in 2014-2017 while PPP, elasticities and MB based misalignments declined in similar fashion (PPP: 4.2 percent to 3.9 percent, elasticities: 3.6 percent to 2.0 percent, MB: 8.9 percent to 2.4 percent). Over the entire sample period, the average misalignment was 4.0 per cent, with the level considered negligible by end of 2017.

The results indicate that misalignment was relatively higher in earlier periods mainly during 2011-2012, which coincides with the Eurozone debt crisis. The misalignment estimates generated using the alternative approaches, particularly PPP show close co-movement with the BEER estimates especially when one examines their turning points.

Table 15: Misalignment- Results of different Approaches Compared

Period	PPP	BEER	Elasticities	MB	Average
2010-2013	4.2	4.1	3.6	8.9	5.2
2014-2017	3.9	2.6	2.0	2.4	2.7
Average	4.0	3.4	2.8	5.7	4.0

4.4 Discussion of Results

From the analysis above, the PPP has revealed the close association between exchange rate stability and price stability. The BEER approach identifies government expenditure, investment, openness, terms of trade and productivity differential as factors with significant influence on the REER. Furthermore, CAB and recurrent government expenditure are negatively correlated. Despite different underlying assumptions, PPP and BEER give very close estimates implying that one of these approaches can be regularly updated to give an indication on the direction of misalignment (suggesting PPP, given less data demands) and the other (suggesting BEER) to be used occasionally to provide some cross-check of the magnitude of misalignment. The close association between PPP and BEER estimates could be attributed to the fact that fundamental factors determining the long run trajectory of the REER happen to be aggregate demand factors with influence also on prices.

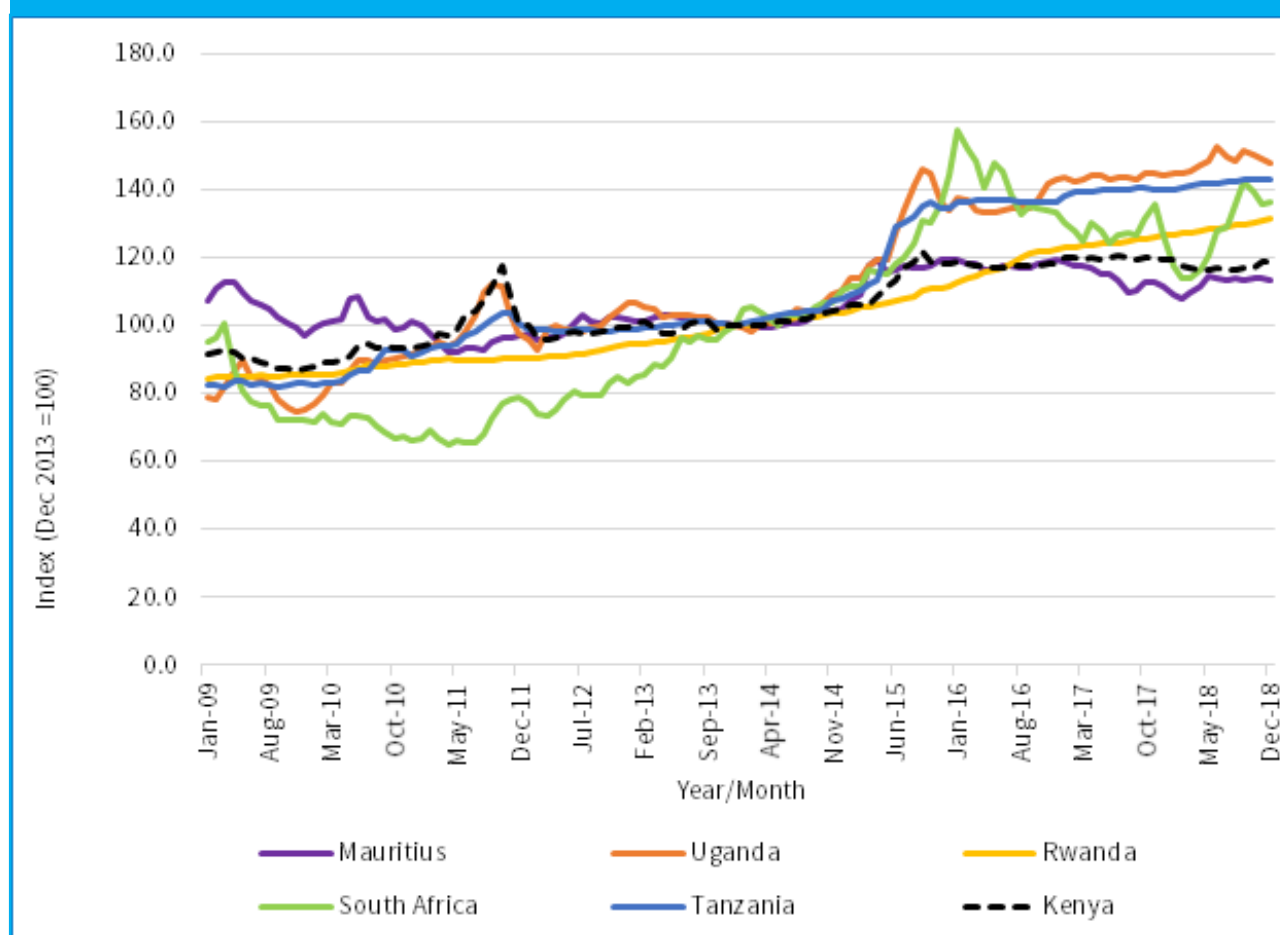
A breakdown of the misalignment estimates indicates that the average overvaluation over the sample period was generally similar across PPP, BEER and Elasticities approaches (2.6 percent, 2.5 percent and 2.5 percent respectively). However, average undervaluation over the sample period based on the three methodologies were slightly varied (5.0 percent for PPP, 4.1 percent for BEER and 2.8 percent for trade elasticities). Overtime, however, all the methodologies indicated declines in levels of misalignment. The BEER methodology showed a decline in the level of misalignment from 4.1 percent in 2010-2013 to 2.6 percent in 2014-107.

The relatively high misalignment in 2011/12 corresponds to various internal and external shocks during this period. In the domestic front, the country was faced with drought and reduced production of agricultural goods. In the external sector, the high global fuel prices and the worsening Eurozone crisis presented major challenges. International prices for crude oil increased from an average of 79.2 US Dollars per barrel in 2010 to an average of 110.6 US Dollars per barrel in 2011 mainly attributed to supply disruptions due to unrests in the Middle East and North Africa and strong global demand (Kenya Economic Survey, 2012). High international fuel prices meant rising domestic prices and instability in foreign exchange markets leading to a sizable depreciation of the shilling. The response was to tighten monetary policy leading to high interest rates during this period, resulting in constrained investment and growth. The macroeconomic instability during this period is captured by movements in all indicators (Table 17 and Figure 14 in Appendix D). Inflation rose from 4.0 percent in 2010 to 14.0 percent in 2011 then to 9.4 percent in 2012. The Kenya Shilling-USD exchange rate depreciated from Ksh. 79.2 per US dollar in Ksh.2010 to Ksh.88.80 in 2011 then appreciated to Ksh.84.5 in 2012. Accordingly, declines occurred in broad money (M3) and GDP growth in the period 2010-2012 as well as widening of the current account deficit.

Business cycle synchronization across countries in the region occurred with implication that global shocks (such as demand shocks, U.S. financial crunch and Eurozone sovereign debt crisis) played a significant role in enhancing exchange rate co-movement and accelerating currency risk (Figure 15). The timing of the depreciations differs somehow, with Kenya's exchange rate movements corresponding closely with those of Uganda and Tanzania, as indicated by depreciations peaking in the three countries in October 2011 and October 2015. Other countries that experienced depreciations were Mauritius in June 2010 and April 2015; Nigeria in January 2015 and September 2016; and Rwanda in November 2016. Carsamer (2016) has noted that trade linkages tend to amplify business cycle synchronization with implication that global shocks (such as demand shocks, U.S. financial crunch and Eurozone sovereign debt crisis) played a significant role in enhancing exchange rate co-movement and accelerating currency risk.

A look at recent movements in macroeconomic variables indicates that macroeconomic stability improved towards 2018, supporting the estimates of reduced misalignment of the real exchange rate. As shown in Table 16 and Figure 16 in Appendix D no major disruptions or shocks are noticeable that would have triggered large real exchange rate misalignments.

Figure 15: Nominal exchange rates (Index of domestic currency units per USD)



5. Conclusion

This study assessed misalignment of the real effective exchange rate (REER) of the Kenya Shilling over the period 2009 - 2017 using the BEER methodology and applying other methodologies for robustness check. The robustness analysis using PPP, Elasticities and Macroeconomic Balance approaches provided the necessary crosscheck mechanism to enhance the credibility of the results.

Overall, misalignment of the Kenya shilling real effective exchange rate declined on average from 4.1 percent in 2010-2013 to 2.6 percent in 2014-2017, suggesting that the country's exchange rate was largely consistent with economic fundamentals. A number of observations are made: first, over 2014-2017, movements in relative prices remained low and displayed some consistency with the reduced change in the nominal exchange rate during this period implying that stability in nominal exchange rates relate closely with stability in prices as proposed under PPP. Second, the shilling was largely undervalued during the study period. Third, the low price elasticity of imports implies that the exchange rate is less effective as a tool for current account adjustment and thus cannot be considered the only panacea for external imbalances. This suggests some role for alternative policies such as adjustments in fiscal policy which appears closely connected with the current account balance. Fourth, results from the BEER and PPP displayed great semblance implying that the PPP could be used to provide a quick check on misalignment given its simplicity and less data demands. The study reiterates the need for sensitivity analysis in the assessment of exchange rate misalignment since the magnitude of misalignment could vary across methodologies owing to the set of built-in assumptions in each approach.

Appendices

There are four appendices to this paper. Appendix A presents the alternative approaches used in the analysis of exchange rate misalignment covering PPP, trade elasticities, BEER and MB methodologies. Appendix B describes the process used to compute the nominal effective exchange rate and the real effective exchange rate. Appendix C provides further description of the Macroeconomic Balance approach. Finally, Appendix D presents some selected economic indicators in tabular and graphical formats.

Appendix A. Methodology

a. Purchasing power parity (PPP).

Conditions for PPP to hold include: fairly homogenous price indices used (e.g. CPI) across countries, low proportion of nontraded goods in the indices and transaction costs that are not too high to limit arbitrage.

Following the approach in Qayyum, Khan, Khair-u-Zaman and Saqib (2005), we consider the case of traded good in which,

$$P_i = S_i P_i^* \quad (6)$$

Where P_i is the price of good i expressed in domestic currency, S_i is the nominal exchange rate expressed in local currency per unit of foreign currency. P_i^* is the price of good i expressed in foreign currency;

When aggregated over all goods, the law of one price yields the PPP equation:

$$P_t = S_t P_t^* \quad (7)$$

Where P_t is price level in home country, S_t is nominal exchange rate and P_t^* is price level in foreign country.

Transportation costs, tariffs and non-tariff barriers are assumed constant overtime, represented by a constant term, β_0

$$P_i = \beta_0 (S_t P_t^*) \quad (8) \quad (3)$$

Expressed in logarithmic form where lower case letters represent logs;

$$p_t = \beta_0 + s_t + p_t^* \quad (9)$$

Rearranging and introducing the error term;

$$s_t = -\beta_0 + p_t - p_t^* + \mu_t \quad (10)$$

s_t , p_t , p_t^* are the natural logs of nominal exchange rate, domestic and foreign price indices respectively while μ_t is the error term.

The exchange rate misalignment is calculated as deviations from the level implied by PPP.

The test for cointegration relies on the Engle-Granger methodology. Engle and Granger (1987) postulate that if two series are cointegrated, then there will exist an error correction representation. In this case,

$$\Delta \tilde{s} = \theta_0 + \theta_1 \Delta(p_t - p_t^*)_{t-1} - \delta[\tilde{s}_{t-1} - \alpha - \beta(p_t - p_t^*)_{t-1}] + \varepsilon_t \quad (11)$$

Where $\tilde{s}$ is the logarithm of the trade weighted nominal exchange rate. Thus, $\tilde{s}$ is the NEER and $(p_t - p_t^*)$ is relative prices (RELP)

The long run relationship is accordingly,

$$\tilde{s}_t = \alpha + \beta(p_t - p_t^*)_t \quad (12)$$

$$\tilde{s}_t = \alpha + \beta_0 p_t + \beta_1 p_t^* \quad (13)$$

If cointegration exists between the variables, then we can estimate the equation. The resulting regression residual series is subjected to stationarity tests e.g. Augmented Dickey Fuller test (ADF). If the residual series is stationary, then we conclude that there exists a long run relationship and weak form PPP is assumed to prevail. Strong-form PPP exists if, in addition to weak-form holding, homogeneity is also satisfied; that is, $\beta_0 = 1$ and $\beta_1 = -1$. If the estimated coefficients are equal and opposite then this implies relative prices affect the exchange rate in a symmetrical fashion; that is, $\beta_0 = -\beta_1$ (Hinkle & Montiel, 1999).

b. Trade Elasticities Approach

Trade balance in terms of domestic currency can be stated as follows:

$$TB = P_t x(q_t, y_t^*) - S_t P_t^* m(q_t, y_t) \quad (14)$$

Where TB is the current account balance, P_t and P_t^* are domestic and foreign price levels respectively, x and m are export and import volumes respectively, y_t and y_t^* are domestic and foreign real incomes respectively, and S_t is the nominal exchange rate defined as domestic price of foreign currency so that an increase represents a depreciation. q_t is the real exchange rate [$q_t = \frac{S_t P_t^*}{P_t}$].

Dividing (8) through by P_t the trade balance can be specified in terms of domestic output:

$$b = x(q_t, y_t^*) - q_t m(q_t, y_t) \quad (15)$$

Totally differentiating (9) and assuming equality between exports and imports ($x=qm$) yields¹:

$$\hat{q} = (-) \frac{(\eta_x \hat{y}_t^* - \eta_m \hat{y}_t)}{(\varepsilon_x + \varepsilon_m - 1)} \quad (16)$$

Where η_x and η_m are income elasticities of exports and imports

ε_x and ε_m are price elasticities of exports and imports

$\hat{y}$ and $\hat{y}_t^*$ is the growth of domestic and foreign incomes respectively, with y^* being a weighted index of foreign economic activity.

The percentage change in the real effective exchange rate ($\hat{q}$) is therefore linked to trade elasticities: export price and income elasticities and also import price and income elasticities. In this case, the gap between the computed current account equilibrating exchange rate adjustment and the actual exchange rate change represents the measure of exchange rate misalignment.

$$\begin{aligned}\Delta LOG(X) = & \beta_0 + \beta_1 LOG(DEF)_{t-1} + \beta_2 LOG(RELPX)_{t-1} + \beta_3 LOG(y^*)_{t-1} + \beta_4 LOG(X)_{t-1} \\ & + \sum_{i=1}^{i=p} \delta_{1i} \Delta LOG(X)_{t-i} + \sum_{i=0}^{i=q} \delta_{2i} \Delta LOG(DEF)_{t-i} + \sum_{i=0}^{i=r} \delta_{3i} \Delta LOG(RELPX)_{t-i} \\ & + \sum_{i=0}^{i=m} \delta_{4i} \Delta LOG(y^*)_{t-i} + \mu_{1t}\end{aligned}\quad (17)$$

$$\begin{aligned}\Delta LOG(M) = & \alpha_0 + \alpha_1 LOG(DEF)_{t-1} + \alpha_2 LOG(RELPM)_{t-1} + \alpha_3 LOG(y)_{t-1} + \alpha_4 LOG(M)_{t-1} \\ & + \sum_{i=1}^{i=p} \varphi_{1i} \Delta LOG(M)_{t-i} + \sum_{i=0}^{i=q} \varphi_{2i} \Delta LOG(DEF)_{t-i} + \sum_{i=0}^{i=r} \varphi_{3i} \Delta LOG(RELPM)_{t-i} \\ & + \sum_{i=0}^{i=m} \varphi_{4i} \Delta LOG(y)_{t-i} + \mu_{2t}\end{aligned}\quad (18)$$

The long run elasticities can be determined using the ARDL models above, so that;

$$LOG(X) = \beta_0 + \beta_1 LOG(DEF) + \beta_2 LOG(RELPX) + \beta_3 LOG(y^*) + \varepsilon_{1t} \quad (19)$$

$$LOG(M) = \alpha_0 + \alpha_1 LOG(DEF) + \alpha_2 LOG(RELPM) + \alpha_3 LOG(y) + \varepsilon_{2t} \quad (20)$$

Where X (M), DEF, RELPX, RELPM, y^* and y are values of exports (imports) of goods and services, GDP deflator, relative price(exports), relative price (imports), foreign real income and domestic real income respectively. β_2 , α_2 and β_3 , α_3 are the long run price and income elasticities of exports and imports respectively. RELPX and RELPM are given by $\frac{P_t}{P_t^* S_t}$ and $\frac{S_t P_t^*}{P_t}$ respectively.

The existence of long run relationships is determined through bounds test in which the null hypothesis $H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$ is tested against the alternative $H_A: \beta_1 \neq 0, \beta_2 \neq 0, \beta_3 \neq 0, \beta_4 \neq 0$. Similarly, the null hypothesis $H_0: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$ is tested against the alternative. $H_A: \alpha_1 \neq 0, \alpha_2 \neq 0, \alpha_3 \neq 0, \alpha_4 \neq 0$.

The Wald test can be applied and the resulting F-statistic examined for its significance. The critical values have been provided by Pesaran et al (2001) and for small samples, Narayan (2005). The critical values include upper and lower bounds. If the computed F-value exceeds the upper bounds, then the existence of a long run relationship is confirmed. On the other hand, if the calculated F statistic falls within the lower bound and the upper bound, the F-statistic result is inconclusive. When the result is inconclusive, an additional test needs to be applied as proposed in Kremers et al (1992). Cointegration is established if the adjustment coefficient or error correction term is negative and highly significant, since it is a reflection of the adjustment toward long run equilibrium as well as cointegration among the variables. Banerjee et al. (1998) provides critical values for the t-test to evaluate the significance of the error correction term in small samples.

c. The Behavioral Equilibrium Exchange Rate approach (BEER)

The Behavioral Equilibrium Exchange Rate (BEER) approach of Clark and MacDonald (2000) attempts to separate the purely normative aspects of exchange rate modelling from the behavioral by adopting a two-step procedure (MacDonald, 2002). In the first step a simple behavioral equilibrium exchange rate relationship is estimated and then in the second stage this estimated relationship is used to construct an assessment of whether the exchange rate is overvalued or not. This approach is motivated theoretically using the Uncovered Interest Parity (UIP) condition which is stated as follows.

$$E_t(\Delta s_{t+k}) = (i_t - i_t^*) \quad (21)$$

Where s_t is the log of the domestic currency price of a unit of foreign currency, whereby an increase implies the currency has depreciated; i_t and i_t^* are nominal domestic and foreign interest rates respectively; Δ is the difference operator; and E_t is the conditional expectations operator.

To convert (15) to a relationship between real variables, we subtract expected inflation differential from both sides of the equation.

$$E(\Delta s_{t+k}) - E_t(\Delta p_{t+k} - \Delta p_{t+k}^*) = (i - i_t^*) - E_t(\Delta p_{t+k} - \Delta p_{t+k}^*) \quad (22)$$

Where p and p^* are logs of domestic and foreign price levels respectively. Equation (16) can be rewritten,

$$q_t = E_t(q_{t+k}) + (r_t - r_t^*) + e_t \quad (23)$$

Where q_t is the actual real exchange rate, r_t and r_t^* are domestic and foreign real interest rates respectively and e_t is the disturbance term.

Equation (17) states that the real exchange rate depends on two elements: the expectation of the real exchange rate in period $t+k$, $E_t(q_{t+k})$ and the interest rate differential, $(r_t - r_t^*)$. Clark and MacDonald (2000) attribute the unobservable expectation of the real exchange rate, $E_t(q_{t+k})$, to fundamentals driving the equilibrium real exchange rate, exclusive of interest rate differential. Hence,

$$q_t' = \bar{q}_t + (r_t - r_t^*) \quad (24)$$

Where q_t' is the current equilibrium exchange rate while $\bar{q}_t$ is the equilibrium real exchange rate component which is determined by fundamentals.

d. The Macroeconomic Balance (MB) approach

The concept was popularized by Williamson (1991, 1994). Williamson coined the expression Fundamental Equilibrium Exchange Rate (FEER) for the sustainable external-based equilibrium real exchange rate. In accordance with Williamson's definition, the FEER is the real effective exchange rate (REER) that simultaneously secures internal and external balances for a country, or for a number of countries simultaneously. Internal balance is the non-accelerating inflation rate of unemployment (NAIRU), reached when the economy functions at full capacity output accompanied by low inflation. External balance is achieved when the balance of payments is in a 'sustainable' position over a medium-term horizon, ensuring external debt sustainability. The real equilibrium exchange rate is the exchange rate that equates the current account to the structural saving–investment balance in the medium term, when the economy is producing at potential output (Isard and Faruquee, 1998; Kincaid et al., 2001)

The MB approach implies three steps:

The first step is to estimate the trend current account that is consistent with the internal balance. The underlying current account balance is estimated by correcting the headline balance for the value of domestic output gap and output gaps of trading partners as well as accounting for recent changes in the real exchange rate. The underlying current account balance is therefore obtained by subtracting from the headline current account balance the short-term effect of output gap and recent changes in real exchange rate. This means that the underlying CA balance is estimated under an assumption that both domestic and foreign economies operate at their potential.

The second step is to estimate an equation linking the current account balance to the set of fundamentals to obtain equilibrium current account balance. An equation is estimated using the cross-country panel regression approach; then the equilibrium current account balance is derived based on the estimated coefficients and taking projected values of fundamentals over the medium-term. The relationship between the current account balance and its fundamental determinants has been estimated by Lee et al. (2008) for a large set of industrial and developing countries over 1973–2004. The regression includes the following variables: budget balance, old-age dependency ratio, population growth, output growth, net foreign assets, oil balance, and relative income. Of these, Budget balance, old-age dependency ratio, population growth, and output growth are calculated vis-à-vis those of trading partners. The coefficients from this regression have been applied in subsequent studies for the assessment of equilibrium current account balance.

The third step is to calculate the required exchange rate adjustment to close the gap between the equilibrium and underlying current account balances. The real exchange rate gap, namely the gap between the current value of REER and the equilibrium REER needed to bring the current account balance to its equilibrium level is computed.

Following the approach in Bayoumi and Farugee (1998) which has been expounded by Isard (2007) and Koske (2008);

$$\frac{CA_t}{Y_t} = \beta_0 - \left[\left(\beta_1 \frac{X_t}{Y_t} + \beta_2 \frac{M_t}{Y_t} \right) \right] [(0.6 \ln q + 0.25 \ln q_{-1} + 0.15 \ln q_{-2})] + \beta_3 \frac{X_t}{Y_t} \ln q_t - \beta_4 \frac{M_t}{Y_t} \ln q_t - \beta_5 \frac{M_t}{Y_t} YGAP_t + \beta_6 \frac{X_t}{Y_t} YGAPF_t \quad (25)$$

Where M, X, and Y are domestic currency values of imports, exports and nominal GDP, respectively. YGAP is the logarithm of the ratio of real GDP (y) to potential output (ypot). YGAPF is the trade weighted YGAP of trading partners obtained by taking the logarithm of the ratio of weighted foreign real income (y*) to potential foreign output (ypot*). Lnq is the logarithm of the REER.

β_1 β_2 β_3 β_4 β_5 and β_6 are calibrated parameters consistent with annual average values of the variables. β_0 is a constant term, β_1 and β_2 are the long run values of the exchange rate elasticity of exports and imports respectively, thus capturing volume effects ($\beta_1 < 0$ and $\beta_2 > 0$). Bayoumi and Faruquee (1998) posit that the impact of exchange rate change on trade volume takes three years with 60percent of the effect being felt in the first year, 25percent in the second year and 15percent in the third year. They suggest that for developing countries, $\beta_1 = 0.53$ and $\beta_2 = 0.69$ in absolute value terms. β_3 and β_4 capture the price effect of exchange rate movements ($\beta_3 < 0$, $\beta_4 < 0$). The net price effect depends on volumes of exports and imports which are unlikely to change in the short run. Assuming that exports and import prices respond fully to exchange rate changes in the short run then $\beta_3 = \beta_4 = -1$. β_5 and β_6 are the elasticities of imports and exports to domestic and foreign economic activity respectively ($\beta_5 > 0$, $\beta_6 > 0$). The suggested values are $\beta_5 = 1.5$, $\beta_6 = 1.5$.

The underlying current account (UCA) is then determined i.e. the current account that corresponds to potential output locally and abroad and the level that is achieved when prices and trade volumes respond fully to the prevailing exchange rate (q_t). The average real exchange rates for current and previous two periods are denoted q_0 . To derive the underlying current account, domestic and foreign output gaps are set to zero and average exchange rates for current and previous two years equated to q_t . Hence, $YGAP = YGAPF = 0$ and $q_{-n} = \dots = q_{-1} = q_0$, with the result;

$$\frac{UCA_t}{Y_t} = \beta_0 + [\beta_1 \frac{X_t}{Y_t} - \beta_2 \frac{M_t}{Y_t}] q_0 + \beta_3 \frac{X_t}{Y_t} q_0 - \beta_4 \frac{M_t}{Y_t} q_0 \quad (26)$$

Subtracting equation (22) from equation (21) provides the relationship between the actual and underlying current accounts.

$$\frac{UCA_t}{Y_t} = \frac{CA_t}{Y_t} - [\beta_1 \frac{X_t}{Y_t} - \beta_2 \frac{M_t}{Y_t}][(q_0 - q_t) + 0.4(q_t - q_{t-1}) + 0.15(q_{t-1} - q_{t-2})] + \beta_3 \frac{X_t}{Y_t}(q_0 - q_t) - \beta_4 \frac{M_t}{Y_t}(q_0 - q_t) - \beta_5 \frac{X_t}{Y_t} YGAPF_t + \beta_6 \frac{M_t}{Y_t} YGAP_t \quad (27)$$

The exchange rate elasticity of the underlying current account (η_{UCA}) can be derived from equation (23);

$$\eta_{UCA} = \beta_1 \frac{X_t}{Y_t} - \beta_2 \frac{M_t}{Y_t} + \beta_3 \frac{X_t}{Y_t} - \beta_4 \frac{M_t}{Y_t} \quad (28)$$

The change in $\ln q$ ($\cong$ the percentage change in q) that is required to adjust the underlying current account ($\frac{UCA_t}{Y_t}$) from its present level to equilibrium position ($\frac{EQCA}{Y}$) is given by¹:

$$\Delta \ln q = \varphi \left(\frac{EQCA}{Y} - \frac{UCA}{Y} \right) \quad (29)$$

Where,

$$\varphi = \frac{1}{[(\beta_1 - 1) \frac{X}{Y} + (1 - \beta_2) \frac{M}{Y}]}$$

Appendix B. Measurement of the Real Effective Exchange Rate

To derive the nominal effective exchange rate, the bilateral exchange rate between the home country i and the trading partner j is converted into index form ($\hat{S}_{i,j}$) using a base year/quarter/month. Thus, the current period nominal exchange rate ($S_{i,j,t}$) is divided by base period bilateral nominal exchange rate (S_{i,j,t_0}) multiplied by 100.

¹¹ $\eta_{UCA} * \Delta \ln q = \left(\frac{EQCA}{Y} - \frac{UCA}{Y} \right)$ so that $\Delta \ln q = \left(\frac{EQCA}{Y} - \frac{UCA}{Y} \right) / \eta_{UCA}$.

$$\acute{S}_{i,j} = \sum_{j=1}^{j=n} \left[\frac{S_{i,j,t} \times 100}{S_{i,j,t_0}} \right] \quad (30)$$

The nominal effective exchange rate, $\tilde{S}$, is simply the weighted average of the index derived.

$$\tilde{S} = \sum_{j=1}^{j=n} \left[\frac{S_{i,j,t} \times 100}{S_{i,j,t_0}} \right] w_{i,j} \quad (31)$$

Which can be rewritten,

$$\tilde{S} = \sum_{(j=1)}^{(j=n)} \acute{S}_{(i,j,t)} w_{(i,j)} \quad (32)$$

$0 < w_{i,j} < 1, j = 1, 2, \dots, n$, so that $w_{i,j} = (w_{11} + w_{12} + w_{13} + \dots + w_{1n})$

Where $w_{i,j}$ is the weight ascribed to trade between the home country i and foreign trading partner j.

The real effective exchange rate is obtained by getting the weighted average of the product of the nominal bilateral exchange rate index and foreign prices and then dividing the product by domestic prices. CPI-based price indices are used in this study.

$$q = \sum_{j=1}^{j=n} \frac{[\acute{S}_{i,j,t} P_{j,t}^*] w_{i,j}}{P_{i,t}} \quad (33)$$

Where $P_{j,t}^*$ is foreign price level for country j and $P_{i,t}$ is domestic price level. The definition of the real exchange rate adopted is such that an increase represents a depreciation of the domestic currency.

Appendix C. Macroeconomic Balance Approach Estimates

In the Macroeconomic Balance (MB) approach, the underlying current account (CA) balance is estimated by correcting the headline CA balance for the value of domestic output gap and output gaps of trading partners as well as accounting for recent changes in the real exchange rate. The equilibrium current account balance is then derived by applying the estimated coefficients of a cross-country panel regression on the values of fundamentals specific to the country whose exchange rate is being assessed. The required exchange rate adjustment to close the gap between the underlying and equilibrium current account balances is then calculated.

We start with the computation of underlying current account (UCA) by adjusting the headline current account with respect to changes in exchange rates and cyclical movements in domestic and foreign economic activity (YGAP & YGAPF) to derive medium term estimates of the current account.

$$UCA = \frac{CA}{Y} - \left(\frac{0.53(X)}{Y} - \frac{0.69(M)}{Y} \right) \left((\log(q_0) - \log(q_t)) + 0.4(\log(q_t) - \log(q_{t-1})) \right. \\ \left. + 0.15(\log(q_{t-1}) - \log(q_{t-2})) \right) + \frac{1.5(M)(y)}{ypot} - \frac{1.5(X)(y^*)}{ypot^*} \\ - \frac{(\log(q_0) - \log(q_t))(X)}{Y} \\ + \frac{(\log(q_0) - \log(q_t))(M)}{Y} \quad (34)$$

Where CA, M, Y, q_t , y, y^* , X, ypot and ypot* are current account balance as reported in BOP accounts, imports, nominal GDP, real effective exchange rate, real income, real foreign income, exports, domestic potential income and foreign potential income respectively. q_0 is the average exchange rate for the current and previous two periods. The coefficients are as suggested in Bayoumi and Faruquee (1998) and Isard (2007).

The computation of the equilibrium current account (CA norm) is based on the coefficients in Lee et al (2008).

$$CA_{norm} = 0.19fbd - 0.12deprd - 1.03popgd + 0.17oilbal - 0.16pcgd \\ + 0.02relpc + 0.37cab(-1) \quad (35)$$

Where fbd , $deprd$, $popgd$, $oilbal$, $pcgd$, $relpc$, and cab are fiscal balance (ratio of the general government balance to GDP) relative to trading partners weighted average, old age dependency ratio (computed as percent of the aged population 65 years and above to the population between 30 and 64) relative to trading partners weighted average, population growth relative to trading partners average, fuel imports as percent of GDP, real GDP per capita growth relative to weighted trading partners average, per capita PPP income in constant international dollars relative to the US level and current account balance as ratio of nominal GDP respectively. The trading partners' weights applied in this study are as provided in Table 2.

The exchange rate adjustment (q_{adj}) to bridge the gap between underlying current account and the equilibrium current account is then computed.

$$q_{adj} = \sigma[CA_{norm} - UCA] \quad (36)$$

Where

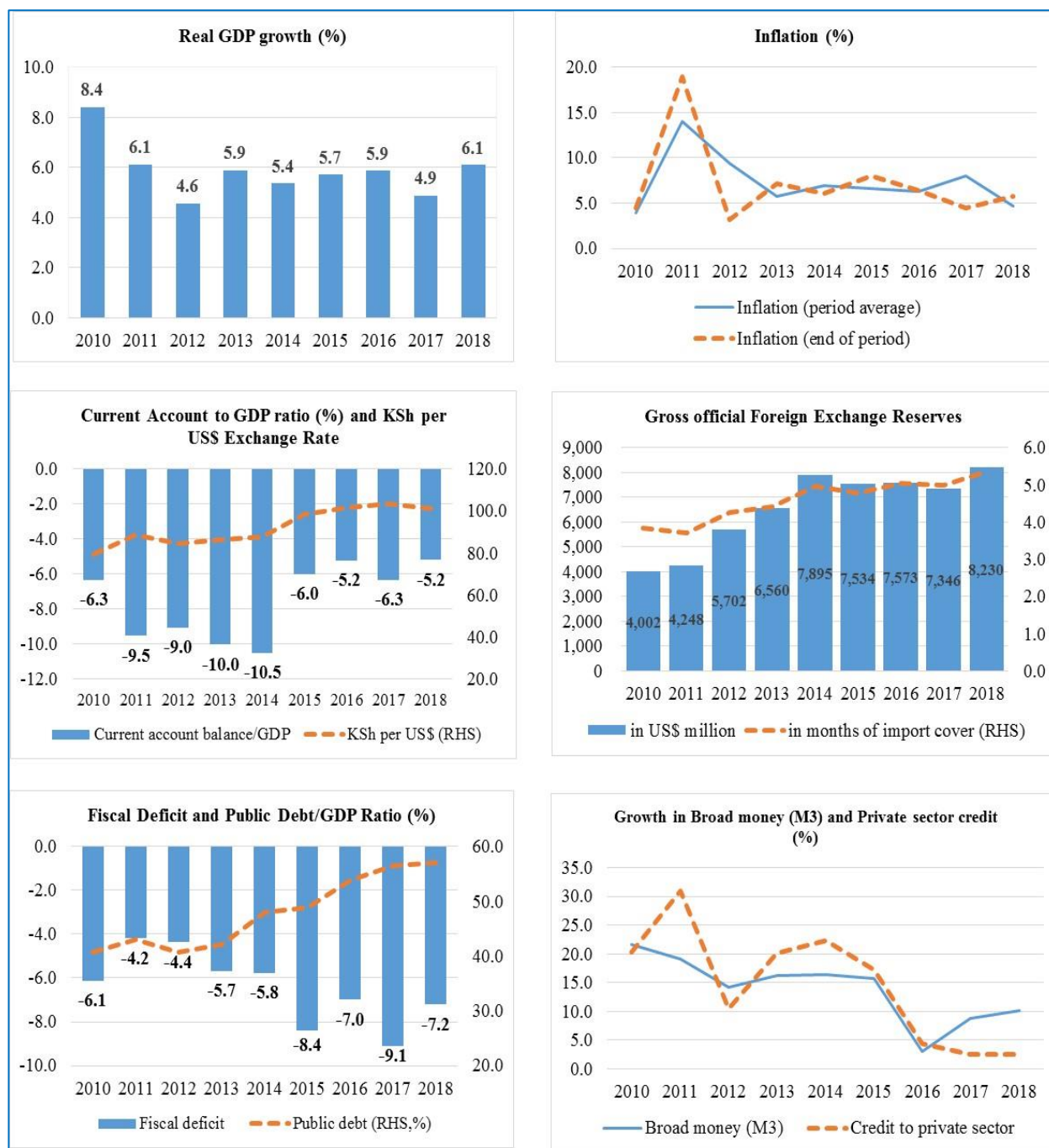
$$\sigma = \frac{1}{\left[(0.53 - 1) \left(\frac{X}{Y}\right) + (1 - 0.69) \left(\frac{M}{Y}\right)\right]}$$

Appendix D. Kenya: Selected Economic Indicators

Table 16: Selected Economic Indicators, 2009–2018

	2010	2011	2012	2013	2014	2015	2016	2017	2018
(Annual Percentage change, unless otherwise indicated)									
Real GDP growth (percent)	8.4	6.1	4.6	5.9	5.4	5.7	5.9	4.9	6.1
Inflation (period average)	4.0	14.0	9.4	5.7	6.9	6.6	6.3	8.0	4.7
Inflation (end of period)	4.5	18.9	3.2	7.1	6.0	8.0	6.3	4.5	5.7
Exchange rate (Kenya shilling/US\$)	79.2	88.8	84.5	86.1	87.9	98.2	101.5	103.4	101.3
Current account balance/GDP	-6.3	-9.5	-9.0	-10.0	-10.5	-6.0	-5.2	-6.3	-5.2
Overall fiscal balance/GDP (percent) ¹	-6.1	-4.2	-4.4	-5.7	-5.8	-8.4	-7.0	-9.1	-7.2
Public debt/GDP (percent) ¹	40.7	43.1	40.7	42.1	48.0	48.8	53.8	56.5	57.1
Gross international reserves									
in US\$ million	4,002	4,248	5,702	6,560	7,895	7,534	7,573	7,346	8,230
in months of import cover	3.9	3.7	4.3	4.4	5.0	4.8	5.0	5.0	5.3
Broad money (M3)	21.6	19.1	14.1	16.2	16.4	15.8	3.0	8.8	10.1
Credit to private sector	20.3	30.9	10.4	20.1	22.2	17.3	4.4	2.5	2.4
¹ Fiscal year to June									

Figure 16: Selected economic indicators, 2009-2018



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