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Equilibrium Real Effective Exchange Rate and Misalignments in Papua New Guinea

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Abstract

The determination of equilibrium real effective exchange rate and misalignments for Papua New Guinea (PNG) is crucial as it would assist the Bank of Papua New Guinea to formulate appropriate exchange rate strategies that would enable price and macroeconomic stability, and promote growth. We apply the single equation Behavioural Equilibrium Exchange Rate (BEER) method and respective PNG economic data for the period 1980Q1-2015Q4 and found real exchange rate to be slightly overvalued in 2015 but undervalued in 2016, both with the same magnitude. These results imply that in PNG real exchange rate is influenced mainly by key macroeconomic fundamentals.

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1. Introduction

Equilibrium real exchange rate (ERER) and real exchange rate misalignment have recently gained prominence in the debates among policy makers, academics, researchers and the public worldwide. ERER is the long-run steady state exchange rate level that ideally achieves macroeconomic stability and growth through attaining internal and external balances of an economy[5]. Deviations from the equilibrium real exchange rate also referred to as misalignments, can either be overvaluations where actual real exchange rate is greater than the equilibrium rate or undervaluations where otherwise is observed. Large and persistent real exchange rate misalignments can have negative consequences to an economy. For example, large overvaluations of exchange rate in a domestic economy could adversely impact on the competitiveness of tradable sector as prices for domestic exports become more expensive compared to the rest of the world. Conversely, if real exchange rate is significantly undervalued, this would translate to inflationary pressures in the economy through imported inflation. Given these potential consequences of real exchange rate misalignments, it is vital to investigate the ERER and corresponding misalignments to guide policy formulation. Hence, the purpose of this study is to calculate the equilibrium real exchange rate and the misalignment for PNG in recent period. In addition, the study would establish long-run determinants of real exchange rate.

PNG does not have an existing model to calculate the equilibrium level of real exchange rate, and the corresponding misalignments, apart from recently published papers. This places policy makers in a challenging situation to pursue relevant macroeconomic policy adjustments to counteract contemporary macroeconomic imbalances. Amidst these imbalances, the Central Bank could pursue exchange rate policies such as devaluation of the exchange rate to remedy adverse situations such as cumulative current account deficits and dwindling foreign exchange reserves, or increase its intervention in the foreign exchange market to prevent currency appreciation in an overheating economy which could impede demand for domestic exports.

From end of 2002 to end of 2012, PNG's real effective exchange rate appreciated by about 43 percent largely attributed to a significant appreciation in the nominal kina exchange rate against US dollar. The nominal kina exchange rate against US dollar appreciated by around 86 percent from US$0.2573 at end of 2002 to US$0.4469 at end of 2013, with the peak of US$0.4845 in April 2012. This large appreciation in kina exchange rate was mainly driven by high foreign exchange inflows from export earnings as a result of favourable international commodity prices, increased export

[5] The internal balance occurs when the demand for and supply of non-tradeable goods are equal while external balance implies reaching the steady state of change in total net foreign assets in an economy (Faruqee 1995, Baffes et al. 1999)

production volumes, and the inflow of investment capital for the construction of the multi-billion dollar Liquefied Natural Gas (LNG) project.

However, during the period 2014 to 2016, foreign exchange inflows were adversely affected due to a downturn in commodity prices, an unexpected oil price shock, and the El Nino. Consequently, the balance of payment position of the country switched from surpluses to deficits. This combined with high import demand and increased Government spending, aimed at sustaining the growth level of the boom period, placed significant stress on the net foreign assets of the banking system. The total net foreign assets declined by about 52 percent to K4, 923.9 million as at end of December 2016 from a high of K10, 209.7 million as at October 2011, mainly attributed to higher import demand and the use of foreign exchange reserves to support the foreign exchange market. The nominal kina exchange rate against US dollar depreciated to around 35 percent from a peak of US$0.4845 in April 2012 to US$0.3150 as at end of December 2016, while, the real effective exchange rate depreciated by around 3 percent over this period.

This outcome has formed views that the appreciation in the real exchange rate during the boom period has not reverted to the equilibrium level (IMF, 2016; Fox and Schroder, 2017). These views are motivated by the theory of Dutch Disease which stipulates that commodity price and natural resource boom would result in an appreciation in the real exchange rate, hence, affecting the tradable sector (Corden and Neary, 1982). This therefore, gave rise to the argument for a devaluation of the kina exchange rate to bring the exchange rate to its equilibrium level, which could strengthen the competitiveness of PNG's tradable sector to address the situation of low foreign exchange inflows and deterioration in the trade balance (IMF, 2016; Fox and Schroder, 2017).

In a recent study, Fox and Schroder (2017) applied the Single-Equation Approach (SEA) using annual data from 1980 to 2015 to model PNG's equilibrium real exchange rate and misalignments, and found the real exchange rate to be overvalued by 22 percent in 2015 and 20 percent in 2016. However, the IMF (2015) in their study found mixed results using four established methods. Whilst Purchasing Power Parity (PPP) approach suggested a 25 percent overvaluation of the kina real exchange rate, the External Sustainability (ES), Macroeconomic Balance (MB) and the Equilibrium Real Exchange Rate (ERER) approaches indicated an undervaluation of the currency between the ranges of 4 to19 percent in 2015.

Given the contrasting findings above, this paper attempts to further test these claims to establish whether the real exchange rate is currently overvalued or undervalued and the size of the misalignments. The study is conducted symmetrically with the methods, model estimator and variables applied by Fox and Schroder (2017). However, few variations were made for comparison purposes. The point of departure of this paper is the use of different data sources and data frequency (we apply quarterly data), and the techniques for deriving sustainable values for macroeconomic

fundamentals which proved to have marked difference in the outcome. The study revealed that real exchange rate was overvalued by 2 percent at the end of December quarter 2015 but was undervalued by 2 percent in corresponding quarter of 2016. The study further confirms that government expenditure, productivity differentials, terms of trade and trade openness have a long-run relationship with the real exchange rate for PNG.

The rest of the paper is organised as follows. Firstly, a brief literature on the theoretical models of equilibrium real exchange rate is outlined. This is followed by the discussion on the methodology. Third, descriptive statistics of the variables are outlined while the fourth section discusses the empirical model. The fifth section covers the interpretation of the results and finally, a conclusion is made with key policy recommendations.

2. Literature review

i. Theoretical review

Studies relating to the equilibrium level of real exchange rate and the degree of misalignments and its determinants have been prevalent both in the developed and developing countries. However, the greater challenge lies with reaching a mutual consensus to apply a wider standard of estimating the equilibrium real exchange rate and its misalignments (Hinkle and Montiel,1999).

The Purchasing Power Parity (PPP) approach and its extensions provide the most fundamental method in estimating equilibrium real exchange rates. This approach is based on the PPP theory, “the law of one price”, introduced by Gustav Cassel (1921, 1922), which postulates that when expressed in one currency; price levels are same in the home and foreign country. PPP approach which is based on the PPP theory advocates a constant long-run real exchange rate that equates the price of a basket of goods in a domestic country to a same basket of goods in foreign country (Rugoff, 1996). The rate relates to the equilibrium real exchange rate. According to PPP, the real effective exchange rate can deviate in the short-run but reverts to this constant equilibrium exchange rate in the long-run. However, most studies did not find a constant equilibrium real exchange rate that is consistent with PPP as the equilibrium exchange rate adjusts overtime in response to changes in other variables. These variables are known as fundamentals and the past and expected values of these fundamentals affect the internal and external balance and thus influence the path of equilibrium real exchange rate over time. Therefore, it is now widely accepted that PPP does not hold overtime, both in its relative and absolute terms, as the equilibrium real exchange rate is not a constant rate but a path of real exchange rates over time.

The disprove of the PPP gave rise to methods which accounted for the time series properties of the real effective exchange rate in calculating equilibrium real exchange rate. Among these methods are two models including the fundamental equilibrium exchange rate (FEER) and behavioural equilibrium exchange rate (BEER). The FEER, also commonly referred to as Macroeconomic Balance (MB) approach, was proposed by Williamson (1985, 1994). He defined ERER as the long-run steady state

(equilibrium) of the real exchange rate that prevails when the economy is in internal and external balance. The internal balance is achieved when the market for non-tradable goods and labour balance out while external balance implies reaching the steady state of change in total net foreign assets in an economy (Faruqee 1995, Baffes et al. 1999). In other words, external balance is the state where an economy's external position is sustainable. This approach focuses only on medium term factors that have persistent influence on external balance, but seldom on very short-term variables that impact on the foreign exchange market regularly. Under this approach, the equilibrium real exchange rate varies overtime as factors impacting on the sustainable internal and external balance adjust.

FEER is a two-step procedure: first, the medium term external balance is identified by equating current account balance to the capital account and second, the market clearing (equilibrium) real exchange rate is derived. Here, current account is composed of the net trade balances, which is a function of the real exchange rate and full employment output of the domestic and foreign economies, and the returns of net foreign assets, which is also influenced by fluctuations in the real exchange rate (Clark and MacDonald, 1998, 2000; Siregar and Rajan, 2006). FEER approach, however, was criticised mainly for its assumption of the sustainable current account as a measure of external balance, which is considered to be more subjective.

Clark and MacDonald (1998) introduced the behavioural equilibrium exchange rate (BEER), often referred to as the Single-Equation Approach(SEA), which focuses directly on estimating long-run relationship between the behaviour of real effective exchange rate and the associated macroeconomic fundamentals. Alternatively viewed, BEER asserts that the movement of the ERER reflects the movement of these fundamental variables. This implies that actual values of the fundamentals are taken into account and not necessarily the medium term equilibrium values as is usually the case in the FEER approach. Hence, the FEER's macroeconomic balance assumption is not necessary with the BEER approach (Siregar and Rajan, 2006). Among others, these fundamental variables could include; government consumption on tradeable and non-tradeable goods; net foreign assets; terms of trade; productivity differentials; trade openness and interest rate differential. These fundamentals mainly influence the long-term behaviour of real effective exchange rate.

BEER approach involves three steps: first, long-run relationships between the prevailing real exchange rate and a set of short-run and long-run economic fundamentals are estimated. Second, the coefficients parameters of the fundamental variables are used to compute the ERER. Third, deviations of the actual real exchange rate from the equilibrium real exchange rate, both for current and long-run are determined. Misalignments derived from the current values of fundamental variables are referred to as current misalignments, and are mainly attributed to the impact of short-term transitory factors and volatility such as property prices and speculative forces, which have short-term impact in the foreign exchange market. On the other hand, the misalignment arising from employing permanent or 'sustainable' values are often referred to as the total misalignment, which captures the effect of the deviations of economic fundamentals from their sustainable values, together with the effect of short-term transitory factors and random disturbances (Clark and MacDonald, 2000). The permanent or 'sustainable' values are derived using various data filtering or smoothing methods.

The macroeconomic fundamentals and the size of their impact vary between different countries underpinned by different structures of the economies, resulting in varying ERER. For instance, in developing countries, the productivity differential between tradable and non-tradable sector is much prominent than in developed countries (Balassa 1964, Samuelson 1964). Further, there is a significant difference in the quality of non-tradeable goods and services between developed and developing countries. This creates the need to build equilibrium real exchange rate (ERER) models that best suits particular regions based on respective fundamentals. Edwards (1989, 1994) as a result, built an ERER model, specifically for developing countries which assisted him and other researches to model long-run relationship between the real exchange rate and fundamental variables for developing countries. For PNG, terms of trade, government expenditure, productivity differentials, debt service ratio, trade openness and interest rate differential were found to be some of the important determinants of real exchange rate (Aipi, 2012; Faal.et.al, 2008; Fox & Schroder, 2017). Also these established key macroeconomic fundamentals are assumed to have long-run relationships with real exchange rate.

In a work-in-progress by the Bank of PNG to apply the existing technical approaches and views shared for a suitable and desired ERER to guide the Central Bank for its exchange rate strategies, the authors chose the SEA approach to frame ERER and the real exchange rate path for PNG. The study concludes that macroeconomic fundamentals have played a pivotal role in determining the long-run path of the real exchange rate.

3. Methodology

We employ the BEER method to model equilibrium real exchange rate and misalignments for PNG based on its efficiency in determining long-run relationship of real exchange rate and its fundamentals and its relevance to the developing countries (Montiel, 1999). The BEER method is a three-step procedure which includes estimation of relationship between RER and current values of economic fundamentals, which leads to finding the current misalignment, the derivation of the sustainable values of long-run fundamentals and the estimation of long-run co-integrating relationship of real exchange rate and the sustainable values of fundamentals, and the determination of the magnitude of misalignment of the RER. This, in theory, is referred to as the total misalignment. Following Clark and MacDonald (1998), we outline the BEER approach as follows:

First, an estimated long-run equation is employed to explain the behaviour of the real effective exchange rate and the associated macroeconomic fundamentals. This is represented in the following:

$$lnREER = \theta' Y_t + \alpha' X_t + \varepsilon_t \qquad (1)$$

Where,

$lnREER$= the actual (observed) real effective exchange rate
Y_t =vector of explanatory macroeconomic fundamentals
θ = vector of coefficients of the fundamentals
α_t = the vector of short-term (transitory) variables and;
ε_t = the error term assumed to be white noise, that is, stationary with zero mean and constant variance.

Equation (1) implies that the actual real effective exchange rate $lnREER$ can be adequately explained by a set of fundamental variables, Y_t, and some transitory variables, X_t, that can affect real exchange rate in the short-run, and the error/disturbance term.

The real effective exchange rate that is determined by employing the current values of economic fundamentals is regarded as the current equilibrium rate ($\widehat{lnREER}$). That is:

$$\widehat{lnREER} = \theta' Y_t \qquad (2)$$

The current misalignment, mis_curr_t, thus, is the deviation of actual real effective exchange rate from the current equilibrium rate. This is represented as follows:

$$mis\_curr_t = lnREER - \widehat{lnREER} = \alpha' X_t + \varepsilon_t \qquad (3)$$

However, as covered in the literature, sustainable (permanent) values of fundamentals, $\overline{Y_t}$ may deviate from their current values, hence, the misalignment derived from the sustainable values, that is, total misalignment is determined.

$$mis\_per_t = lnREER - \theta' \overline{Y_t} \qquad (4)$$

Employing equation 2, equation 4 can be decomposed into current misalignment and the effect of the deviations of current and sustainable values of the fundamentals. That is:

$$mis\_per_t = \left(lnREER - \widehat{lnREER}\right) + \theta'(\overline{Y_t} - Y_t) \qquad (5)$$

When taking equation 3 into consideration, equation 5 can be re-written in this form:

$$mis\_per_t = \alpha' X_t + \varepsilon_t + \theta'(\overline{Y_t} - Y_t) \qquad (6)$$

Equation 6 implies that the misalignment in the real exchange rate in the long-run is a function of three main components: the transitory (short-run) effect, random disturbance and the effect of the deviation of economic fundamentals from their sustainable values.

For this paper, equation 4 is applied with an interest to find the permanent misalignment derived from the sustainable values of economic fundamentals. Five

economic fundamentals representing vector $\overline{Y_t}$ of the equation include the terms of trade, government spending, productivity differential, net foreign asset and openness. These variables are selected based on the contributions of Edwards (1989), Montiel (1999) and Faruqee (1995) to theory. In addition, the selection of variables was for the results to be comparative to related PNG specific studies such as Fox and Schroder (2017), IMF (2015), Aipi (2012); Sampson and Kauzi (2009) and Faal et al (2008). Most of these variables are relevant for developing economies and are based largely on simple neoclassical theory which assumes that price of tradable goods are equal across countries, but prices of non-tradable goods vary, hence, impacting the real exchange rate (MacDonald and Ricci, 2003). However, relaxing this assumption could also assist explain the movements in real exchange rate attributed to the changes in prices of the tradable goods. In either case, selected fundamentals explain why real exchange rate deviate from the PPP (MacDonald and Ricci, 2002).

The following are priori expectations for the various fundamentals based on theory:

i. Terms of trade - an increase in TOT or commodity price would appreciate the REER. Higher TOT results in increased export earnings in the tradable sector. This could induce higher overall wages, which could spill over into higher demand and prices of the non-tradable goods. Alternatively, increase in TOT could generally result in higher personal wealth, which stimulates aggregate demand and, hence, prices of non-tradable, resulting in appreciation of real exchange rate. A decline in TOT would result in depreciation of REER.

ii. Government spending - an increase in government spending has positive influence on the REER, in particular, on non-tradable goods. This is most common in many developing economies where government spending is largely concentrated on non-tradable sector of the economy. This leads to a general increase in the price level of goods and services in the domestic economy, hence, positively impacts on the REER.

iii. Productivity differential - as productivity increases in the tradable sector in an economy relative to major trading partners, real exchange rate would tend to appreciate. This increase in productivity will induce higher wages in the tradable sector, and if wage equal across sectors, this would push up the prices of the non-tradable goods. This is commonly termed as the Balassa-Samuelson effect.

iv. Net foreign Asset - an increase in net foreign asset position of a country would cause an appreciation in the REER. A higher NFA balance would imply an increase in the foreign exchange inflows, particularly from capital investment and export and service receipts, hence a build-up in the foreign assets of a country relative to its stock of foreign liabilities. This could translate to the increased government revenue, inducing an increase in expenditures. Since, government funding is mainly to the non-tradable sector, this would exert

upward pressure on the prices of goods and services in this sector, thus resulting in appreciation of the real exchange rate.

v. Openness - openness in an economy is commonly measured by various trade restrictions that are applied. Lower trade restrictions would encourage higher trading between home country and its trading partners, and therefore lead to cheaper imports into the home country. In contrast, exerting higher trade restrictions could result in higher import costs being passed onto domestic prices of tradable goods, hence, leading to rise in the price level and the real exchange rate (Goldfajn and Rodrigo, 1999).

I. Data

The time series data for the variables used in this empirical work was sourced mainly from BPNG and other various sources (See Table 3 in the Appendix). These variables include the real effective exchange rate (REER), government expenditure (GEXP), net foreign assets (NFA), productivity differentials (PROD), terms of trade (TOT), and trade openness (OPEN). The observed period for this study is quarterly data from 1980 to 2015. Chart 1 depicts the trend of the variables over the study period with the description of each variable given below.

i. Real Effective Exchange Rate(REER)

The real effective exchange rate (REER) is the trade-weighted average of a country's currency relative to an index or basket of other major currencies, adjusted for the effects of inflation. This is derived as follows[6]:

$$REER_{country\ i} = \sum_{j}^{n} trade\ weight_{country\ j}\ x\ RER_{country\ j} \quad (8)$$

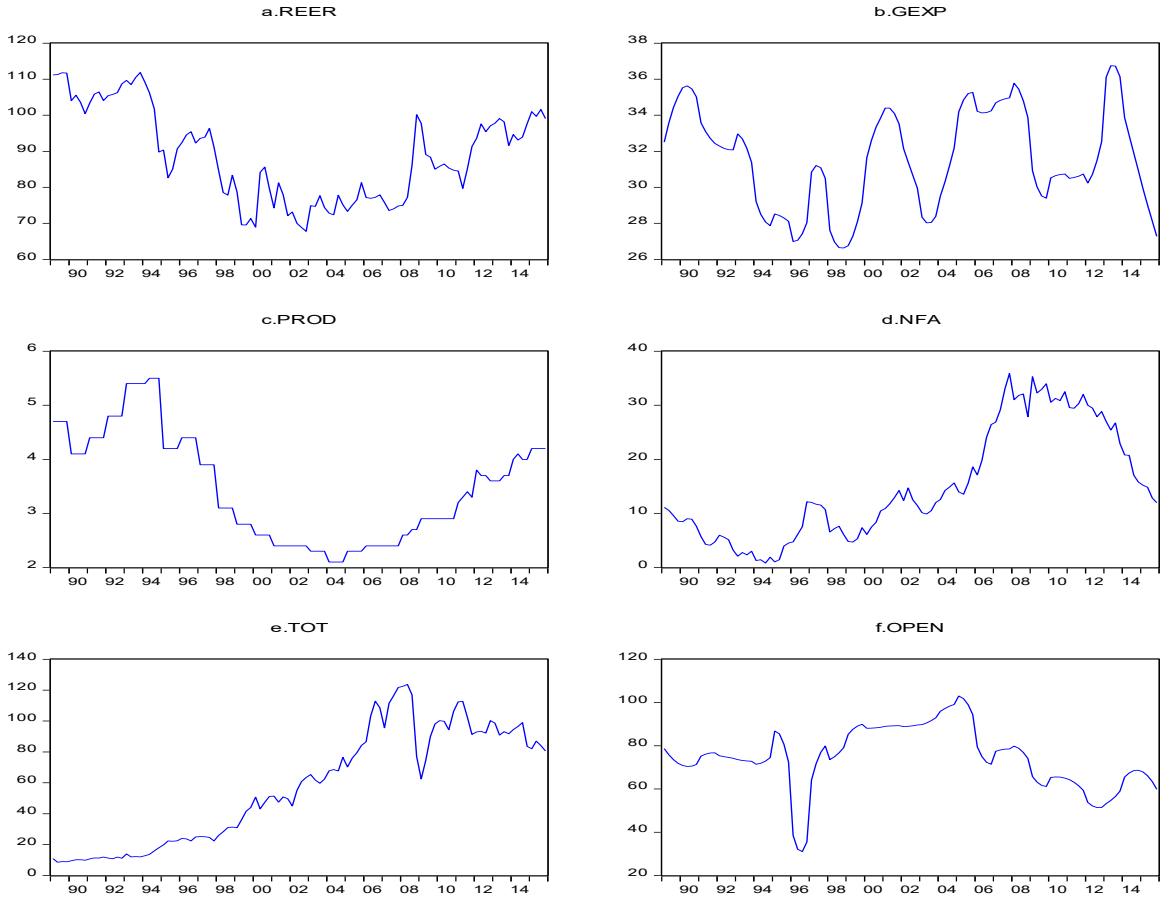
Where, $Country_i$= the domestic country, $Country_{\ j} = 1, 2 \ldots, n$ = country 'i's' major trading partners and real exchange rates are in logarithms. In this case, the domestic country in PNG and some of its major trading partner countries based on the total trade shares include Australia, Japan, China, Singapore, New Zealand, United States and Europe[7]. $RER_{country\ j}$= bilateral real exchange rates of country i and its major trading partners, equivalent to:

$$RER_{\ country\ j} = NER_{country\ j}\ x\ \frac{P_{country\ i}}{P_{coutry\ j}} \quad (9)$$

[6] Note that there are other various methods used in calculating REER. For example, IMF calculates REER by taking the nominal effective exchange rate (NEER) and adjusting it by relative price levels.

[7] In respective years, countries which have trading shares of more than one percent are included in the quarterly REER calculation.

Chart 1: Data Series for 1990-2015



Where, $NER_{country\ j}$ is the nominal bilaterial exchange rates between $Country_i$ and its trading partners, $Country_j$, measured as foreign currency per unit of domestic currency. $P_{country\ i}$ = the price level in $Country_i$ and $P_{coutry\ j}$ = the price levels in $Country_j$. The price levels are commonly measured in Consumer Price Index (CPI).

Equation 8 and 9 implies that an increase in RER attributed to a rise in the nominal exchange rates or domestic price relative to foreign prices, would cause an increase (appreciation) in the REER. REER reflects a country's competitiveness relative to its trading partners. Hence, an increase in REER would mean that PNG is less competitive relative to its trading partner countries as prices of a basket of goods is more expensive in PNG compared to the same basket of goods in trading partner countries.

Chart 1(a) show that REER in PNG over the study period generally depict a trough-shaped behaviour, that is, a period where REER was high, followed by a decline then an increase again. In the early 1990's, REER was at very high levels. It subsequently depreciated by around 25 percent from 1994, reaching the lowest around the last quarter of 2002. From 2002 to 2015, REER appreciated by about 46 percent. However, its behaviour varied within the periods. The period of depreciation featured

some macroeconomic instability including an unsustainable external balance, resulting from cumulative fiscal deficits, which led to kina devaluation and the subsequent float of kina, particularly, in 1994. After three years, external shocks of El Nino and subsequent Asian Financial Crisis induced another significant devaluation. These nominal exchange rate depreciations triggered high domestic inflation levels. The upward path of REER over the second period coincided with more than a decade of consecutive economic growth attributed to macroeconomic and political stability, favourable commodity prices and exports, and the construction of PNGLNG project which had an appreciating effect on the nominal exchange rate.

ii. Government Spending

Total government spending as a proportion to the nominal Gross Domestic Product (GDP) is used for the government spending variable. That is:

$$GEXP = \frac{GEXP}{NGDP} \qquad (10)$$

Government expenditure as a proportion of nominal GDP for PNG over the period was generally steady, with an average of around 32 percent. This mainly reflects the proportionate change in spending by the government with respective to changes in the nominal GDP. However, in real terms, the ratio increased since 1994. Government expenditure pattern in PNG closely follow the government revenue pattern. The sharp increases in government expenditure during the 2000s reflected periods of favourable revenue inflows and economic growth of the country (Chart 1(b)).

iii. Productivity Differential(PROD)

The ratio of real GDP per capita of PNG to trade-weighted real GDP per capita of PNG's major trading partners is used as a proxy for productivity differentials between PNG and its major trading partner countries. This is represented as:

$$Productivity\ Index_{country\ i} = \frac{Y_{i_t}}{\sum_j^n Trade\ Weighted\ x\ Y_{f_{j,t}}} \qquad (11)$$

Where,
Y_{i_t} = real GDP per capita of domestic country.
$Y_{f_{i,t}}$ = the real GDP per capita of trading partner countries.
$Country_{\ j}$ = 1, 2 …., n are $Country_{\ i}{}'s$ major trading partners

An increase in productivity index of PNG would imply that PNG has become comparatively competitive relative to its major trading partners. Similar to the 'Dutch Disease' effect, PNG would be attracting factors of production and capital inflows from foreign countries due to higher productivity a particular sector(s) of the domestic economy. Chart 1(c) show that the productivity levels in PNG declined in the later years of the 1990's and early 2000's, reaching the lowest in 2004. It gradually increased afterwards until end of 2015, which is the period of high economic growth in PNG.

iv. Net Foreign Asset(NFA)

NFA is the stock of PNG's foreign assets minus its foreign liabilities. The ratio of NFA to nominal GDP is used as follow:

$$NFA = \frac{NFA}{NGDP} \quad (12)$$

Chart 1(d) shows that NFA as a ratio of nominal GDP declined in early 1990s, reaching its lowest in 1994. In line with GDP growth, it gradually increased from around 1 percent in March 1995 to around 14 percent in June 2005. NFA further increased to a peak of 36 percent in December 2007. Over the period 2008 to 2012, it remained steady at around 30 percent, thereafter, gradually declined to 6 percent in December 2015.

v. Terms of Trade(TOT)

The commodity terms of trade (TOT) used is the ratio of relative price of export to the import price of PNG.

$$TOT_i = \frac{EP_i}{EP_j} * 100 \quad (13)$$

Where

TOT_i= the terms of trade for home country;
EP_i = the export price index for home country *i* and
EP_j = the export price index (import prices) for home country 'i's major trading partners, where

$$EP_f = \sum_j^n trade\ weight_{country\ j}\ x\ Export\ Price\ Index_{country\ j} \quad (14)$$

Country j = 1, 2, …..,n are home country 'i's major trading partners.

If TOT is greater than 100, this would imply an improvement. If otherwise, it would imply worsening. An improvement in TOT would mean, either export prices of the PNG have increased or import prices of trading partners have declined or combination of both. Alternatively, a worsening TOT would imply that, either export prices have declined or import prices have increased or the combination of both. In PNG, TOT has generally been increasing over the years due mainly to upward movement in mineral prices as mineral exports composed more than 70 percent of PNG's exports (Aipi, 2012). Over June 2006 to September 2008, TOT index soared above 100. After the commodity price slump at end of 2008 to 2009, the trend steadily declined (Chart 1(e)).

vi. Openness(OPEN)

Openness measures how open a country is in relation to its trade policies and restrictions. Total merchandise trade as a proportion of nominal GDP is used as a proxy for trade openness.

$$OPEN = \frac{Expors+Imports}{NGDP} x\ 100 \qquad (15)$$

If OPEN is greater than 100, this would imply that PNG has less restrictive to trade policies. Chart 1(f) depicts that PNG faired through the study period generally within the range of 60-80 percent. Over the period, 2005 to 2015, openness declined implying that restrictions towards trade increased. One of the main reasons for trade restrictions, in particular, 2014 and 2015, was the foreign exchange shortages in the foreign exchange market which continue to adversely affect trade.

II. Empirical Method

Since we are interested in establishing the long-run co-integrating relationships, we apply the Fully Modified Ordinary Least Square (FMOLS) estimator developed by Phillips and Hansen (1990) to establish the long-run relationship of REER and the various fundamentals. FMOLS is widely used for cointegration modelling and is preferred over the ordinary least square (OLS) estimator as it corrects for the problems of long-run endogeneities and serial correlation in the regressors of OLS. It is also suitable for regressing variables of different order of integration and data with small sample size. The long-run relationship is specified in a single equation as follows:

$$lnREER = \partial_t + \theta' \overline{Y}_t + \varepsilon_t \qquad (16)$$

Where,

∂_t= constant
Y_t= vector of sustainable values of macroeconomic fundamentals $(\underbrace{TOT}_{+/-}, \underbrace{OPEN}_{-}, \underbrace{PROD}_{+}, \underbrace{GOV}_{+}, \underbrace{NFA}_{+/-})$
θ = vector of coefficients of the fundamentals
ε_t = the error term assumed to be white noise, that is, stationary with zero mean and constant variance.
$lnREER$ = the sustainable value of REER.

Equation 16 implies that the fitted value of REER would represent the equilibrium real exchange rate (ERER). The real exchange rate misalignment (also permanent misalignment rate) would reflect effects of short-term factors, the disturbance term and the deviations of the sustainable economic fundamentals from their current value. The misalignment is calculated as follow:

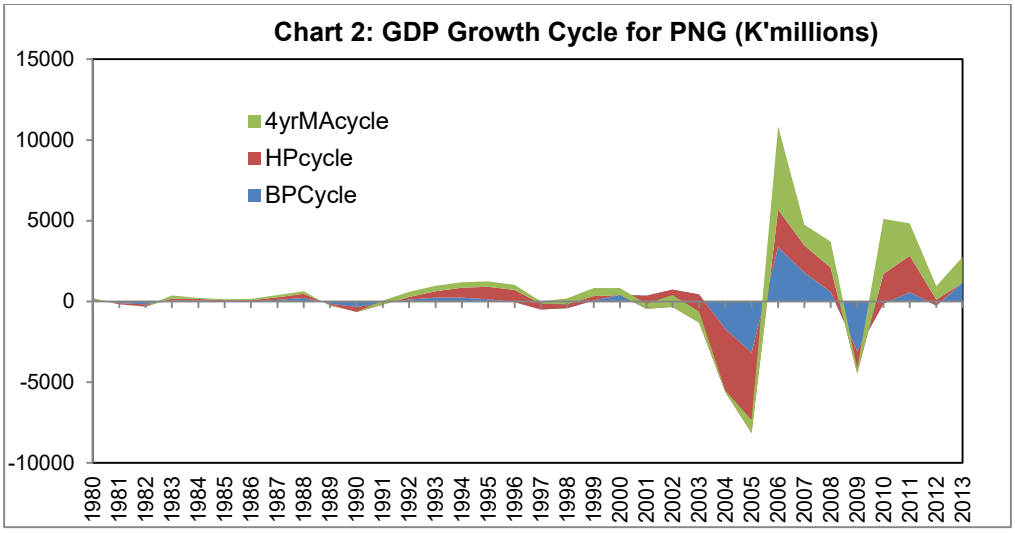
$$RER_{mis_t} = \frac{RER_t - ERER_t}{RER_t}$$

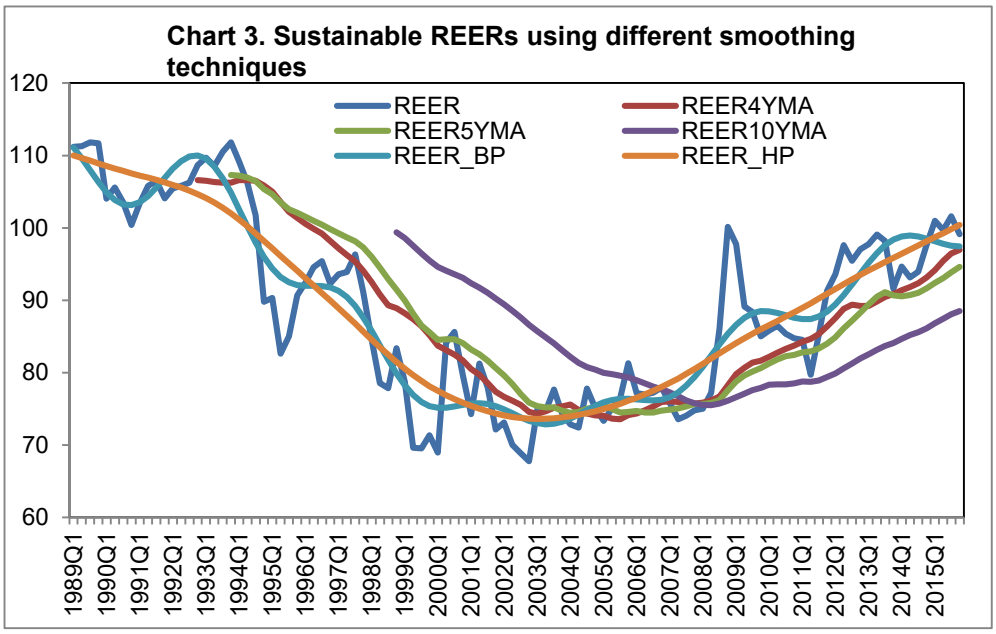
If $RER_{mis_t} > 0$, then it would imply overvaluation, but undervaluation if $RER_{mis_t} < 0$.

We next derive the sustainable (long-run) values of the macroeconomic fundamentals. This is the permanent trend component of the variables after filtering the exogenous shocks and decomposing from its transitory component. We used a 4 year moving average filter to smooth out the cyclical variations and other exogenous shocks. The selection of four-year period is based on the business cycle of the economy. Chart 2 indicates that it takes about four years for the economic growth of PNG to revert back to the mean, reflecting the business cycle of PNG. The cycle is clearer towards to end of the period. The selection of the four-year period is also close to the standard five year moving average recommended by Edwards (1989) and Elbadawi (1994).

Fox and Schroder (2017) counter-argued that the use of five year moving average would not adequately smooth out the severe shocks PNG experienced in the recent years, hence, applied the 10 year moving average. However, we still argue that the use of the 10 year moving average would result in over smoothing of the variables, thus distorting and discarding important features of real exchange rate which could have otherwise reflected the structural adjustments of the economy caused by changes in economic fundamentals overtime. In addition, since the model is estimated using sustainable values of fundamentals, the misalignments emanating from the model would adequately capture the effect of short-run fundamentals together with various shocks and deviations of the fundamentals from their sustainable values.

We also applied other common filtering methods such as Hodrick-Prescott (HP) filter (Hodrick and Prescott, 1997) and Christiano-Fitzgerald band pass filter (CF) (Christiano and Fitzgerald, 1999) to compare the sustainable values derived from the use of the four year moving average. See Chart 3 for REER, as an example, with its sustainable values derived by various filtering methods. The smoothed REER series generated by HP (REER_HP) and CF (REER_BP) filters, with the recommended five year moving average, (REER5YMA) trend closely with the four year moving average (REER4YMA) compared to the ten year moving average filtered series (REER10YMA).





Before estimating the model, the stationarity of the data is tested using the Dickey-Fuller GLS unit root test. Table 1 show the outcome of the Dickey-Fuller GLS unit root test on the variables. The test indicates that variables are a mixer of I(0) and I(1), that is, they are integrated of order 0 and 1, or are stationary either at levels or first difference. Productivity differentials (lprod), Net Foreign Assets (lnfa) and Openness (lopen) are stationary at levels, I (0), while real effective exchange rate (lreer), government expenditure (lgexp) and terms of trade (ltot) are stationary at first difference. Since FMOLS is designed to correct for the problems of long-run endogeneities and serial correlation in the regressors of OLS, both the I(0) and I(1) variables are employed in the model.

Table 1. Dickey-Fuller GLS Unit Root Test					
Variables	Levels		First Difference		Stationary
	Intercept	Intercept & trend	Intercept	Intercept & trend	
lreer	-0.98	-0.82	-2.38**	-3.06	**I(1)**
lgexp	-1.02	-1.29	-3.25***	-3.24	**I(1)**
lprod	-2.14**	-2.35	-1.07	-1.29	**I(0)**
lnfa	-1.41	-3.21**	-1.50	-1.84	**I(0)**
ltot	-0.57	-0.88	-1.73*	-2.37	**I(1)**
lopen	-1.69*	-1.70	-2.18	-2.23	**I(0)**
Significance Level	Critical Values				
1%	-2.59	-3.65	-2.59	-3.65	
5%	-1.94	-3.09	-1.94	-3.09	
10%	-1.61	-2.79	-1.61	-2.79	

III. Results and interpretation

The results of the long-run model are presented in Table 2. Various scenarios were estimated with the selection of the 'best' specification. Comparisons of the estimated results were also made with the model selected for Fox and Schroder (2017).

Table 2: The long-run relationship between REER and the fundamentals				
Independent	**1**	**2**	**3**	**4**
LGEXP	0.03	0.66	0.53	1.75
	(0.09)	(0.10)***	(0.07)***	(0.41)***
LNFA	0.13	-0.02	-	0.17
	(0.02)***	(0.02)	-	(0.06)***
LPROD	0.67	-	0.26	-
	(0.08)***	-	(0.06)***	-
LTOT	-0.08	-0.23	-0.12	0.15
	(0.03)***	(0.04)***	(0.04)***	(0.05)***
LOPEN	0.4	-0.4	-0.16	-0.71
	(0.1)***	(0.06)***	(0.05)**	(0.09)***
Constant	1.76	4.61	3.36	4.48
	(0.35)***	(0.27)***	(0.23)***	(0.23)***
Trend	0.001	0.004	0.002	-0.007
	(0.00)**	(0.00)***	(0.00)***	(0.004)*
R^2	0.988	0.968	0.98	0.86
Lc	0.80	1.0	0.947	0.48

***,**,*statistical significance at 1%, 5% & 10%. Sample period 1989-2015.

Column 1 incorporates all the fundamental variables. Almost all the fundamentals are highly significant in explaining the long-run movements of the real effective exchange rate. However, government spending is insignificant, contrasting the established view.

A large proportion of government spending in PNG is on consumables or non-traded goods, thus, it should have significant impact on the price level of goods in the non-tradable sector and the overall economy. In addition, given the structural underpinnings of the economy, increased spending by the government should translate to higher import demand, hence, impacting on the real exchange rate movements through its influence on nominal exchange rate. Fox and Schroder (2017) found evidence of this and proved that government spending is highly significant in explaining real exchange rate movements. This specification is not considered. Column 2 excludes productivity differential and is estimated as a replica to the Fox and Schroder's (2017) selected model. The authors' basis of excluding productivity differential was primarily based on their argument that the mineral sector which contributes a significant proportion of GDP growth in PNG, is capital and skill intensive, most of which are sourced from foreign countries. Therefore, with its inclusion, the model could generate subjective outcomes. Nonetheless, we assume that the skills transfer process from foreign to local labour has occurred over the start of these resource projects. Hence, in the current period, there should be a greater proportion of skilled local labour compared to foreign-sourced-labor, validating its inclusion in our preferred model specified in column 3. The result shows government expenditure to be highly significant together with the terms of trade and trade openness. However, net foreign asset was found to be insignificant. BPNG only uses its foreign reserve, which is the major component of NFA, to smooth out volatilities in the foreign exchange market. This means that NFA would be a short-term factor and not long-term, hence, explaining its insignificance. This finding is corroborated by Faal et al (2008) who also found NFA to be insignificant. This specification is not considered. Column 3 is the preferred model specification which excludes net foreign asset, but includes productivity differential due to its significance as per the model and the reasoning provided above. Model 3 is also selected on statistical grounds, that is, the model is more fitted with a higher r-squared compared to that specified in column 2. It is sensible to select a model which has better fit. Column 4 is estimated by Fox and Schroder (2017) which excludes productivity differential but includes the net foreign asset. The significance of the net foreign asset in column 4 can be attributed to the different data sources used by the studies. Fox and Schroder (2017) sourced NFA data series from the External Wealth of Nations II database used by Lane and Milesi-Ferretti (2007) and World Development Index (WDI) while we applied the total net foreign asset position of BPNG.

We apply the Hansen Instability test to check for model stability and possible co-integration among the variables. The null hypothesis of the test indicates that the parameters of the model are stable and co-integrated. The L_c test statistics of 0.95 indicates that the model is very stable with the parameters being highly co-integrated. This implies that their long-run relationship between real effective exchange rate and the fundamentals is authentic.

We thus, examine this long-run relationship between the variables. Since all variables are in logarithm (log) form, the estimated parameters are explained in elasticity. The following are the observations from the model:

(i) A 10 percent increase in government expenditure will result in a 5.3 percent increase in REER. This is as expected. In PNG, a greater proportion of government spending is inclined towards the non-tradable goods, hence, its impact on the price level. Further, nominal exchange rate can be influenced if government spending ends up stimulating import demand if it undertakes capital investments. This has been noticeable in recent years.

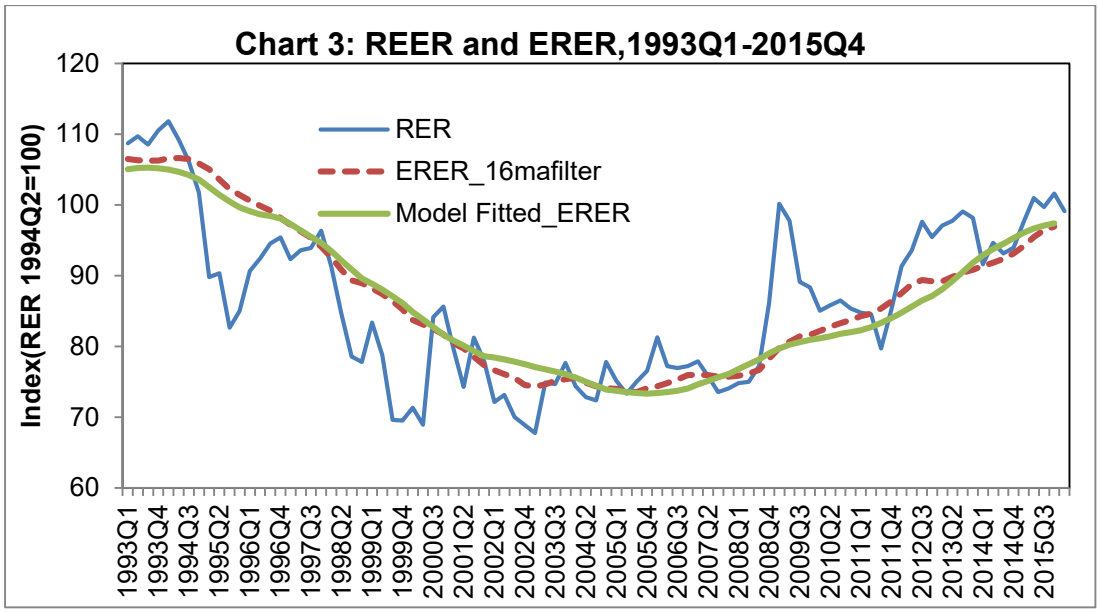
(ii) A 10 percent increase in productivity differentials will result in an increase of 2.6 percent in REER. As domestic productivity increase, it attracts factors of production including capital, labour and other investments from overseas, hence, exerting an upward pressure on the nominal real exchange rate, and thus, an increase in REER. This is similar to 'Dutch Disease' impact where resources are diverted from the low productive non-tradable sector to the more productive tradable sector of the economy. This also fulfils theory where if wage is equalised across sectors, productivity in the tradable sector of the economy would push up prices in the non-tradable sector and the overall economy

(iii) A 10 percent increase in the Terms of Trade (TOT) will result in 1.2 percent decrease in REER. This result is not anticipated as terms of trade should intrinsically have a positive influence on REER in PNG due to the country's dependency on export commodities which are mainly influenced by movements in international commodity prices. Export commodity prices are volatile in nature while import prices are steadier since they are mostly composed of prices of manufactured goods. Aipi (2012) found TOT to be insignificant in explaining REER movements in the long-run but in the short-run, TOT was found to be significant and had a positive impact on REER. The negative relationship here is similar to the findings of Faal et al (2008) but contradicts that of Fox and Schroder (2017).

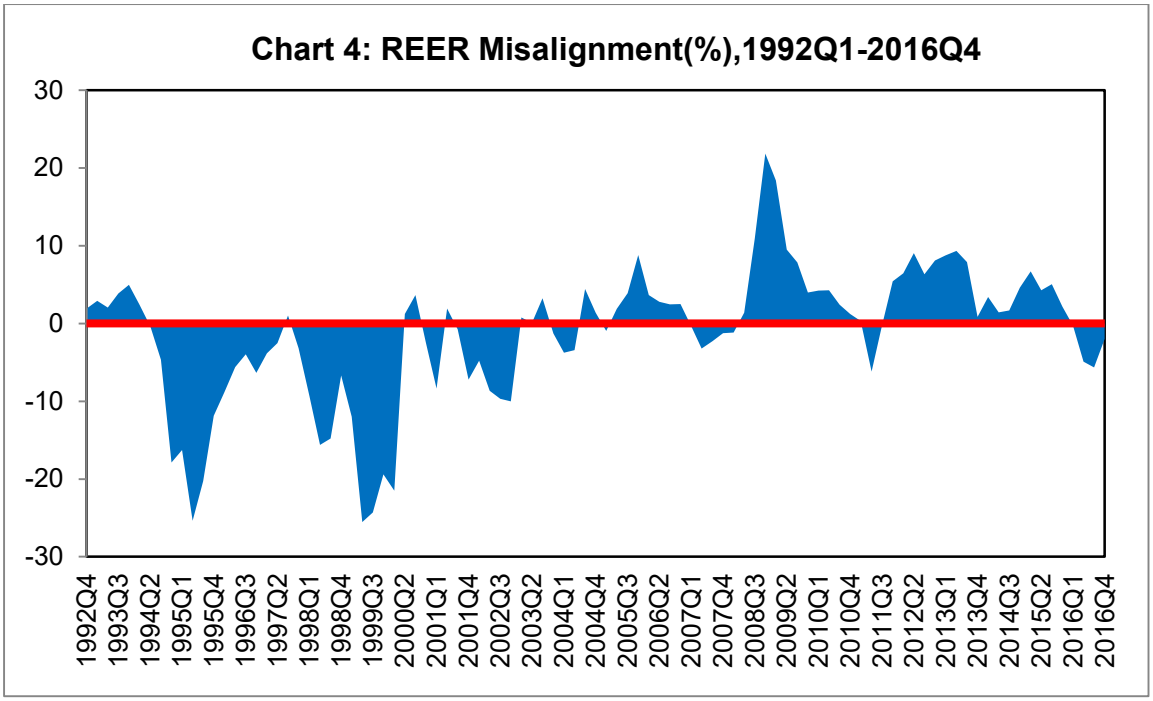
(iv) A 10 percent increase in the trade openness will cause the REER to fall by 1.6 percent. Since PNG is less restrictive to trade, trading with its partner countries increases, hence a negative relationship exists. This is in line with the negative relationship of the TOT and ERER.

Chart 3 plots the real effective exchange rate against its equilibrium values from the long-run model estimate and its sustainable value derived from the use of 16 quarter (4 year) moving average filter. Many studies apply the sustainable values of the real exchange rate as the equilibrium value to calculate the misalignments. Both equilibrium values trend together while the deviations of real exchange rate from the

equilibrium values denote either overvaluations or undervaluations in the real effective exchange rate over the period under study.



The real exchange rate misalignments over the study period are shown in Chart 4. The large misalignments reflected various large shocks to the economy. In particular, large undervaluations in the first half of the period particularly, the period after 1994 and 1997 is caused respectively, by the impact of large devaluations of kina exchange rate against US dollar, owing to sustained fiscal deficits and unsustainable external balance, and the El Nino and the Asian Financial Crisis. The lagged effect of the shocks further added to the persistency of the misalignments. Between 2002 and 2015, several other large shocks were experienced which contributed to large and persistent overvaluations of the real effective exchange rate. These include very high commodity prices around 2008 through to 2013, the large capital inflows associated with the construction of the multi-billion dollar PNG Liquefied Natural Gas (LNG) project, and increased government spending targeted to counteract the effects of Global Financial Crisis (GFC) of 2009. The effect of short-term fundamentals on prices and nominal exchange rate also added to the magnitude of the misalignments of the respective periods. Over 2014 and 2015, the real effective exchange rate was overvalued on average by 4 percent. At the end of December quarter of 2015, real effective exchange rate was overvalued by around 2 percent. However, in the December quarter in 2016, there was an undervaluation of 2.0 percent.



The magnitude of misalignment for 2015 and 2016 contrasts the findings by the IMF (2015) and Fox and Schroder (2017). Whilst the IMF (2015) found the real effective exchange rate to be mixed, that is, three approaches indicating an undervaluation of the range of 4-19 percent and one with 25 percent overvaluation for 2015[8], Fox and Schroder (2017) found overvaluations of 22 percent and 20 percent for 2015 and 2016, respectively. The variances could be attributed to different data sources and different modelling approaches. For example, the approaches applied by the IMF (2015), differs from that employed by Fox and Schroder (2017) and this paper. This paper departs from the Fox and Schroder (2017) at the point of data sources, data frequency and the filtering methods for calculating the sustainable values.

Although not reported here, we reproduced the results, this time using the annual data, but the four year moving average filter to derive the sustainable values of the fundamentals. The model found that the real effective exchange rate is overvalued by about 3 and 4 percent in 2015 using the model fitted equilibrium and the sustainable value of REER, respectively, and undervalued by 1.28 percent for 2016 with the use of the sustainable value of REER.

[8] The equilibrium exchange rate approaches applied by IMF (2015) include the ES, PPP, MB and ERER. The PPP indicated an overvaluation while the other three indicated undervaluation. The misalignment study was assessed relative to August 2015.

Conclusion

In this study, we calculate the equilibrium real exchange rate and misalignments of the real exchange rate in PNG using reduced form single equation of the Behavioural Equilibrium Real Exchange Rate (BEER) approach. In doing so, we established some key macroeconomic fundamentals that influence the real effective exchange rate in the long-run, with the use of the Fully Modified Ordinary Least Squares (FMOLS) estimator. We found government expenditure, terms of trade, trade openness, and productivity differentials to have significant long-run relationship with the real exchange rate. Further, our analysis revealed that the real exchange rate was overvalued in last quarter of 2015 but has depreciated with a minimal undervaluation in the December quarter of 2016. This result provides evidence that the actual real exchange rate movement is largely driven by the fundamentals at present. Hence, if the Central Bank had devalued the currency in 2015 or 2016, then the result show that the combined devaluation by the Bank and the resultant depreciation due to fundamentals would significantly depreciate the real exchange rate, which would have been inflationary. This is in view of the four years consecutive increases in inflation from 2012 to 2016. In PNG, since the floating of the currency, fundamentals have played an important role in determining the movement of the real exchange rate and its equilibrium value. Hence, direct influence on the exchange rate without adjustments to fundamentals can cause imbalances. However, the Bank of Papua New Guinea should be mindful of persistent misalignments which may have negative impact on the growth and stability of economic fundamentals.

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Appendix

Table 3. Data Sources	
Variables	**Sources**
Real Effective Exchange Rate	BPNG Quarterly Economic Bulletin(QEB)/National Budgets
Government Expenditure	World Development Index (WDI) and Quarterly Economic Bulletin (QEB)
Productivity Differentials	BPNG Quarterly Economic Bulletin(QEB)/National Budgets
Net Foreign Assets	BPNG Quarterly Economic Bulletin(QEB)
Terms of Trade	BPNG Quarterly Economic Bulletin(QEB)
Trade Openness	BPNG Quarterly Economic Bulletin(QEB)