Energy Prices and the Real Exchange Rates: A South African Perspective

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Abstract: This study investigates the relationship between energy prices and the real effective exchange rate in South Africa. There is much evidence in the literature to suggest that the performance of open economies, like South Africa, are highly susceptible to exchange rate volatility that result from rapid fluctuations in energy prices, and hence the need for this study. I use yearly data for the period 1970 to 2014 to estimate a long-run co-integration relationship between the real effective exchange rate and its fundamentals *viz.* the terms of trade, the Balassa Samuelson effect, the net foreign asset position, trade openness, fiscal balance and the real interest rate. Using long-run co-integration testing techniques and procedures, I provide evidence for the existence of energy currencies in South Africa. The findings of this study are in line with the existing literature, of a long-run equilibrium relationship between the real effective exchange rate and its fundamentals. The application of the DOLS (Dynamic Ordinary Least Squares) methodology suggests that there is a negative long-run equilibrium relationship between the real effective exchange rate and the terms of trade. Hence, an increase in the terms of trade results in a decrease in the real effective exchange rate, *ceteris paribus*, other real exchange rate fundamentals *viz.* the Balassa Samuelson effect, the net foreign asset position, trade openness, fiscal balance and the real interest rate, have also been found to be significant determinants of the long-run real effective exchange rate. However, the real interest rate was found to have transitory effects, which is also in-line with the existing literature.

Key Words: Energy Terms of trade, Real effective exchange rate, Vector Error Correction Model, Dynamic Ordinary Least Squares.

I. INTRODUCTION

Before the democratic transition that took place in 1994 in South Africa, there were internal and financial sanctions on the apartheid government which were driving the country's economy to a downfall. However, after the transition took place in 1994, the economic performance of the country improved, and started to take shape for prosperity. This is evidenced by the fact that the economy of the country recorded a growth rate of 3.3% from 1994 to 2012 (Ali *et al.*, 2015). Ever since the democratic transition took place, South Africa has been regarded as the most advanced economy in the African continent. This is because it is endowed with a variety of natural resources which contribute to generation of profits and economic growth (Ali *et al*., 2015).

South Africa has an open economy which trades aggressively within the world economy, as it is dependent on the import and exports of goods and services for survival. It has been highly commended as the leader and a competitive producer of not just raw materials but also value added goods. However, like any other developing economy, it remains highly susceptible to trends in the economies of its major trading partners, namely the United States (US), the United Kingdom (UK), Europe and the Far East. This includes exchange rates instabilities which negatively impact the value of the country's currency and consequently hinder the daily functioning of the country's foreign markets (Ali *et al*., 2015).

Exchange rates are regarded as an important tool in measuring a country's competitiveness, which is why a strong exchange rate would imply that goods produced locally are more expensive in relation to goods produced internationally. This phenomenon can be viewed from a nominal and a real perspective. The real part of this concept states that a real exchange rate is the "relative prices of foreign produced goods and services to domestically produced goods and services" (Dauvin 2014). Therefore, it is a measure of the quantity of real GDP of other countries that a domestic country gets for a unit of its GDP. The nominal exchange rate on the other hand is defined as "the value of domestic currency expressed in terms of foreign currency per domestic currency" (Dauvin, 2014. 6).

When it comes to the link between energy prices and the real exchange rate, research has mainly focused on two topics: the impact of oil prices on the US dollar and its adverse effect on non-oil sectors known as the Dutch disease or the resource curse (Amano and Van Norden, 1998). Consequently, the relevance of crude oil and coal on the global economy can never be disregarded considering their significance as a source of earnings for several countries and that is a source of energy for most modern economies. The relationship that exists between energy prices and the real exchange rate has been studied by several researchers, due to its importance especially for developing countries (Ali *et al.*, 2015). Energy prices are determined internationally expressed in terms of US dollar. Clearly this has important implications for the SA economy and the rand which affects both consumption and use of these commodities in the country. Furthermore, random changes in energy prices may also cause macroeconomic instability, more especially in developing economies which rely on the imports and exports of these commodities as sources of income.

However, while Africa consists of a large subset of developing nations, little or no attention has been given to study these relations within it. Having said that, South Africa alone is said to be the largest importer of oil and the largest exporter of coal in Africa. Internationally, coal is the most used primary fuel which accounts for about 36% of total intake of the world’s electricity production (Erdal *et al.*, 2007). On average, 77% of South African energy requirements are delivered by coal (Erdal *et al.*, 2007). This is likely to continue for the next two decades, due to the unavailability of suitable alternatives. The country exports about 21% of its coal production whilst the rest feeds into the various other local industries. At present, South Africa does not have a proven oil and gas reserves and produces oil and gas from coal. Most of the country’s crude oil is imported from outside the country while it imports about 95% of its crude oil requirements. This makes crude oil the single largest imported component (Erdal *et al.*, 2007).

With fewer studies having recognized the role played by energy prices in determining the long-run exchange rate in South Africa, this study will examine the existence of a long-run relationship between energy prices and the real exchange rate in South Africa, mainly through the terms of trade channel. Other studies have used the terms of trade channel to examine this relationship, but mainly for a panel of countries. To the best of the present researcher’s knowledge, this study is the first one to conduct the same analysis for a single country. It would help to determine whether the South African rand is an energy currency or not. The understanding of this relationship, is important for policy makers as it would assist in formulating an adequate policy decision on what policies to adopt to manage uncertainties in the exchange rates, resulting from energy price fluctuations.

To test for this linkage, I will utilize a Vector Autocorrelation, Vector Error Correction Model and Dynamic Ordinary Least Squares econometric techniques. This will be achieved by assessing the long run cointegrating relationship and the long run elasticities of the real exchange rate in South Africa to its economic fundamentals namely, the energy terms of trade, the Balassa Samuelson effect, the net foreign asset position, trade openness, fiscal balance, and the real interest rate.

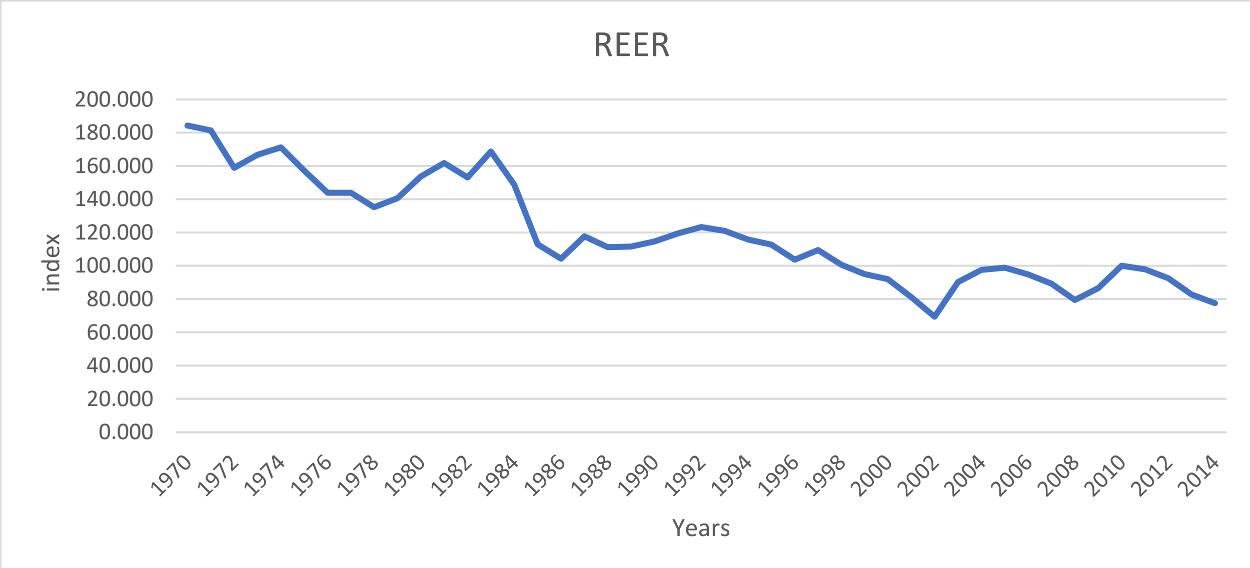
The rest of the study is structured as follows: Section Two will provide the overview of the concept of real exchange rates in SA and the evolution of energy prices. Section Three will review the relevant theoretical and empirical literature. In Section Four, I will develop the methodology and explain the methods and data used in this study and outline the variables used. Section Five focuses on the findings of the study and Section Six concludes and provides some policy recommendations.

II. ENERGY PRICES AND REAL EXCHANGE RATES IN SOUTH AFRICA

The movements of the real effective exchange rate can be seen in Figure 1 below. During the 1970's, South Africa's exchange rate policy mirrored volatile developments on the international front, and during the period under review there were several significant regime shifts (see also Kahn, 1992). These regime changes were not only of a technical nature but also related to changes in policy objectives. Until 1979, the exchange rate was essentially fixed, being pegged to one currency or another.

The South African rand experienced a fall in its value after the apartheid era, particularly in the early 2000's. The effect of this drastic decrease has shown up as higher inflation, when compared to SA's trading partners. The rand value went down by almost 15% from 1994 to 2003 and again in 2014. These real exchange rates fluctuations remain a concern for policy makers and businesses, as they have a negative impact on trade flows. Furthermore, investment decisions might be hindered as a result of such fluctuations, hence it makes it important to investigate the causes of these real exchange rates movements (Frankel, 2007).

Figure 1: Trends in Real Effective Exchange Rate (REER).



Source: ***Authors own estimates***

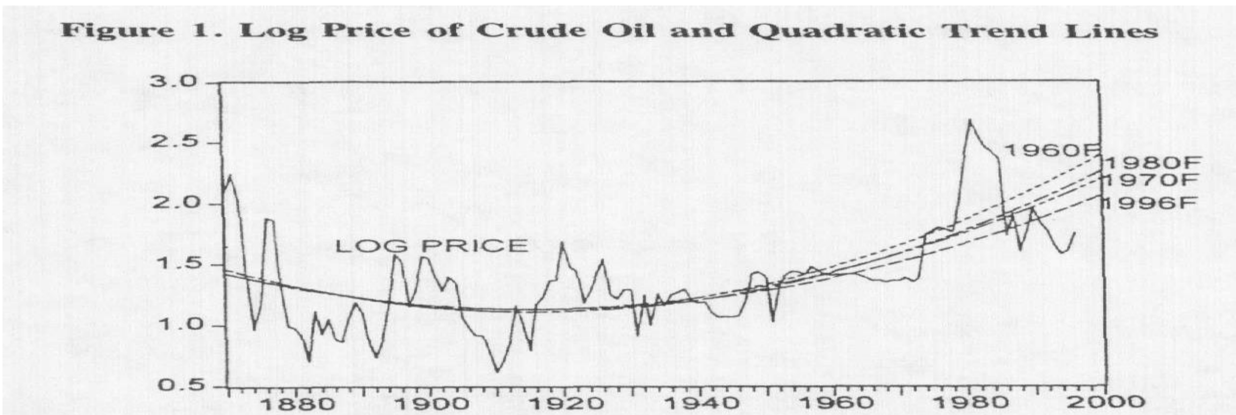
It has been shown that during the 1990's, the real exchange rate was fairly close to its equilibrium value, hence the deviation from this value has been attributable to its fundamentals. Large declines in exchange rates were observed from 1996, 1998 and in the period 2001-2002. Authors who had evaluated the equilibrium real exchange rate concluded that it is the 2001 exchange rate crisis that left the rand undervalued at a rate of 20%, it appeared to recover in 2003. To this day, these trends have continued to be observed as the value of the rand has declined further (Frankel 2007).

Evolution of energy prices and trends in energy market developments

Given that the country imports roughly 95% of its crude oil requirements, this is the largest import item in the balance of payment of the country. Furthermore, the price of crude oil is determined on an international level and the US dollar is used as the measure of its value. This creates a problem in countries like South Africa which are presently faced with currency depreciation. The weaker the rand, the more expensive it becomes to import crude oil hence leading to higher domestic fuel prices (Pindyck, 1999).

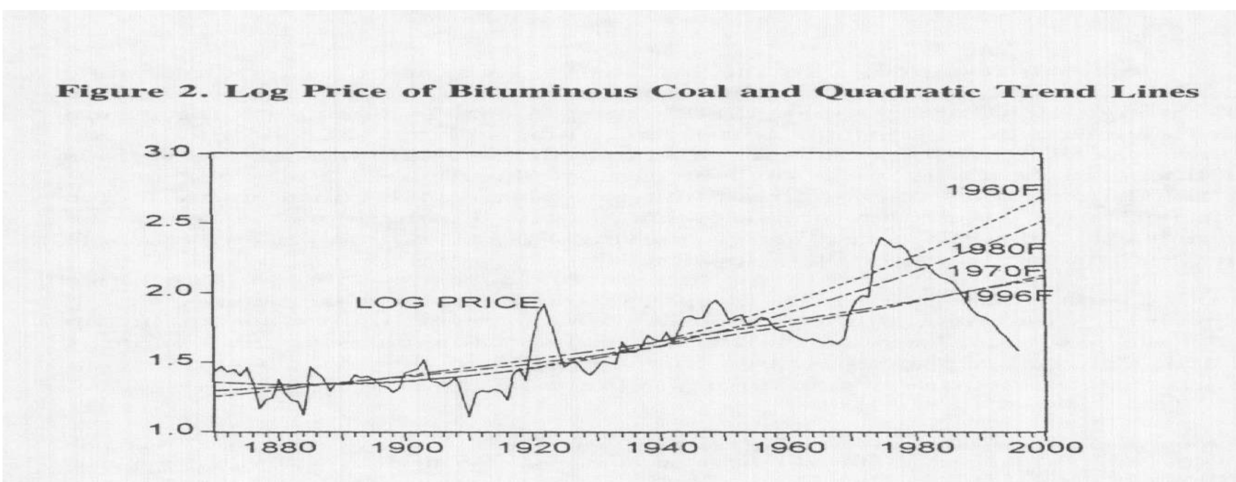
The coal production, on the other hand remains the most important production activity in South Africa, as it accounts for about 93% of electricity generation and about 30% of liquid fuels. However, statistics have shown that the domestic prices of both types of coal had been following an upward trend year after year, with the prices of anthracite coal rising more rapidly than the price of bituminous coal. The prices of exports on the other had is volatile, and the question is what accounts for these volatilities. Evidence suggests that the likely cause is the exchange rate volatility and the number of other costs associated with the exports of goods (Pindyck, 1999).

Figure 2: Past trends in energy market developments (Crude oil price)



Source: ***Pindyck (1999)***

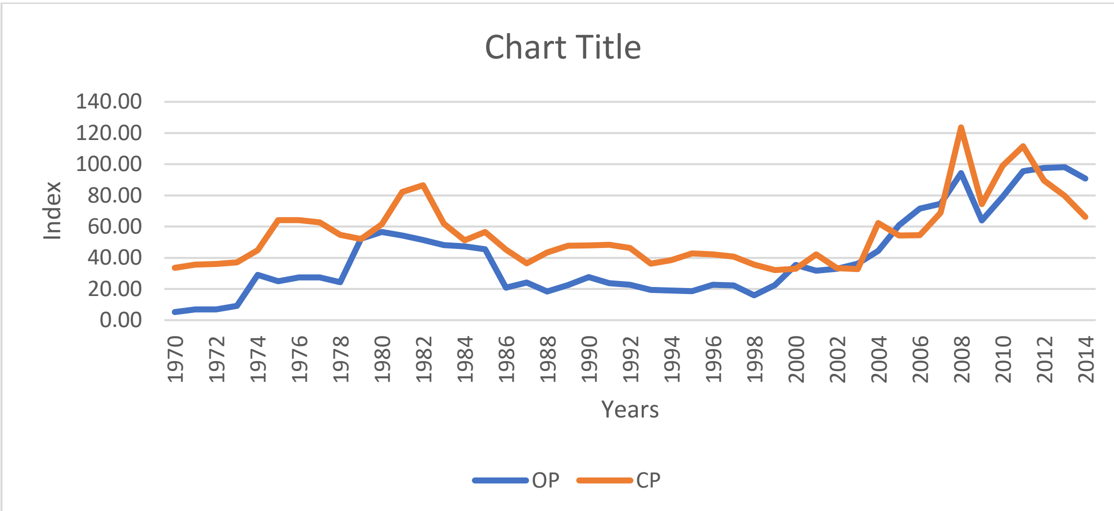
Figure 3: Past trends in energy market developments (Coal price)



Source: ***Pindyck (1999)***

From Figure 2 and 3 above, it is evident that the prices of oil and coal both declined from the year 1870 to 1900, which was the period in which production was starting to be observed at a larger scale. From 1900 up until the oil shock of the 1970's, fluctuations in these prices have been considerably close to its mean value, suggesting the phenomenon of mean reversion. From 1973 to 1981 both oil and coal prices increased drastically and by mid-1980 they seemed to have returned to their normal levels (Pindyck, 1999).

Figure 4: Recent trends in energy market developments (Crude oil and coal prices)



Source: ***Author's own estimates***

Figures 2, 3, and 4 above, suggest two basic characteristics of long run price evolution. Firstly, these energy prices are mean reverting as they seem to return to their long-run equilibrium value, however the speed of adjustment to the long-run mean is very slow taking up to a decade to go back to its equilibrium value. Secondly, the trend line is said to fluctuate as the sample size is increased.

III. THEORETICAL FRAMEWORK AND LITERATURE

a. Theoretical Foundations

Different approaches exist when it comes to measuring a country's real exchange rate. These stem from the traditional Purchasing Power Parity (PPP) theory (MacDonald and Dias, 2007). The Purchasing Power Parity Theory documents that nominal exchange rates should adjust to offset the changes in the relative price level, hence, the real exchange rate should remain constant over time. However, the literature on exchange rates has shown that real exchange rates are non-stationary. In addition, if these are found to be mean reverting to some extent due to use of more sophisticated data, the speed of adjustment to the equilibrium values is very slow. Hence, the deviations from the equilibrium value of real exchange rates cannot be explained on the basis of the PPP theory (Wu, 1999).

Because of the limitation of the PPP theory in explaining the equilibrium real exchange rates, several recent sophisticated approaches had been utilized by recent studies. These model the real exchange rate as a function of different economic fundamentals, therefore, permitting the equilibrium exchange rate to vary over time. The theoretical framework is usually consistent with the monetary approach and the macroeconomic balance approach. There are several variations of the macroeconomic balance approach. These include the Fundamental Equilibrium Exchange Rate (FEER) approach proposed by Williamson (1994), the Natural Real Exchange Rate (NATREX) proposed by Stein and Paladino (1999) and lastly the approach that has recently been utilized by the International Monetary Fund (IMF) (External Balance Assessment). Another recent and popular approach to the equilibrium real exchange rate is referred to as the Behavioral Equilibrium Real Exchange Rate (BEER) approach, proposed by Clark and MacDonald (1999).

This research aims to use the last of these approaches namely the Behavioral Equilibrium Exchange Rate Approach to model the equilibrium value of the real effective exchange rate of South Africa. The use of the BEER approach in this thesis draws heavily on work by Clark and MacDonald (1999). These studies make use of the interest rate parity condition:

$$E_t(\Delta s_{t+k}) = -(i_t - i_t^*) \quad \ldots 1$$

where s_t represents the foreign price of a unit of domestic currency, $i_t$is the nominal interest rate, Δ is the difference operator, E_t is the conditional expectations operator and $(t + k)$ defines the maturity period of bonds. This can be converted to real terms by simply subtracting the inflation expectation differential from both sides of the equation. Doing this and rearranging gives:

$$\hat{q}_t = E_t(q_{t+k}) + (r_t - r_t^*) + e_t \quad \ldots 2$$

where q_t is the *ex-ante* exchange rate, $r_t$is the *ex-ante* real interest rate and e_t is the error term. We assume that the unobserved component $E_t(q_{t+k})$ represents the effect of the different economic fundamentals of the real exchange rate other than the interest rate. Hence, the current equilibrium exchange rate is inclusive of both the systematic and the interest rate differential components.

Several economic fundamentals that induce a variation of the real exchange rate have been identified in literature. However, these differ with each country specification. In the case of South Africa $\hat{q}_t$ has been said to be a function of:

$$\hat{q}_t = f(BS, TOT, FB, NFA, TO) \quad \ldots 3$$

where *BS* represents the Balassa Samuelson effect which is the productivity differential of South Africa, *TOT* shows the terms of trade or commodity prices of South Africa relative to the equivalent foreign variable. *RIR* denotes the real interest rate differential of South Africa, *FB* is the fiscal balance of the country as a proportion of the country's GDP minus the equivalent foreign ratio. *NFA* will give the net foreign asset of the country relative to the country's GDP and *TO* is the country's trade openness (Ricci, 2005). Thus, the empirical analysis of the real effective equilibrium exchange rate is assumed to be a function of all the above-mentioned variables. In the analysis of this study, $\hat{q}_t$ will be given as the function of all these variables and the real interest rate differential *RIR*, which mainly affect the real effective exchange rate of South Africa (Ricci, 2005). Hence, the form of the equation to be estimated in this paper is:

$$\hat{q}_t = f(TOT, BS, NFA, TO, FB, RIR) \quad \ldots 4$$

We expect a positive or negative relation between the real effective exchange rate of South Africa and the terms of trade, the interest rate differential, trade openness, fiscal balance and net foreign asset position. However, we expect a positive relation between real effective exchange rate and the productivity measure, namely, the Balassa Samuelson effect.

b. Review of Empirical Literature

Given the wide-ranging nature of the literature, the brief review presented is not exhaustive and focuses mainly on the studies that are relevant for this study through either the methodology used or an application of South African data. One such study is by Holtemoller and Mallick (2013) which used a sample of 69 countries to model the long-term equilibrium relationship between the REER and its key macroeconomic determinants. Applying data from 1970 to 2006 in a BEER framework, the authors can identify macroeconomic variables (terms of trade, the current account, the country's openness, GDP and exchange rate regime) that reveal a long-run relationship with the REER and interpret movements away from the equilibrium level as misalignment. A notable finding by the authors was that the nature of a country's exchange rate regime has an impact on the extent of currency under or over-valuation with highly flexible currencies showing lower misalignment dynamics. It was concluded in the study that high misalignment (that is also supported by low currency flexibility) can help cause a currency crisis such that policymakers need to be aware of the extent of a currency's misalignment and the potential contribution to a currency crisis that exchange rate misalignment poses.

As in the market for commodities, energy prices are determined by supply and demand. The changes in these prices and their important role in the energy sector has evoked several researchers and policy-makers' interests. Coudert *et al*. (2015), assessed connections between the terms of trade and real exchange rate of commodity-producing countries considering both the short and long run with attention paid to non- linearities. The question addressed in this case was: what is the terms of trade impact on the real exchange rate due to oil price volatility? (Coudert *et al*., 2015). The hypothesis formulated was that the real exchange rate of commodity exporting countries and terms of trade are closely linked when commodity markets are highly volatile (Coudert *et al*., 2015).

If it happens that the results obtained conform to the hypothesis, this relationship between the commodity terms of trade and the real exchange rate should be revaluated to account for non-linearity. The scholars make use of non-linear model in order to test this hypothesis (Coudert *et al*., 2015). A panel of two groups of countries is considered, consisting of 17 countries that are oil exporters and 52 that are commodity exporters over the period of 1980 to 2012. They first found the equilibrium value of the real effective exchange rate by means of having estimated the long run co-integration relationship between the real effective exchange rate and its fundamentals, which is in line with the estimation of the Behavioral Equilibrium Exchange rate approach by Alberola *et al*., (1999). Secondly they employ the Panel Smooth Transition Regression model in order to estimate the short run adjustments to this equilibrium value (Coudert *et al*., 2015).

The results they obtained tend to confirm what other scholars have done. Firstly, coefficients were positive and significant at all levels and the signs are what could have been expected. Therefore, a rise in the Net foreign asset position and the terms of trade led to an appreciation in the real exchange rate, and the terms of trade in this case are an important determinant of the real exchange rate which is in line with what Cashin *et al*., (2004) have observed. When they went on to test for the null hypothesis of linearity at a 5% level of significance, the results obtained revealed that the null hypothesis is rejected at a 5% level of significance which indicated that the explanatory variable will differently affect the exchange rate dynamics depending on oil variability in the oil market. All in all, it is noted that terms of trade are an important determinant of all groups of commodities (including oil and coal) (Coudert *et al*., 2015).

In connection with the above study, Dauvin (2014) in his research examined the energy prices and the real exchange rate of commodity exporting countries. First, he provided perceptions on the connection between energy prices and the real exchange rates of countries that export fossil fuel products, which would assist in determining whether there are energy currencies. Second he assessed whether oil has a non-linear effect on the real exchange rate of energy exporting countries (Dauvin, 2014). This study is closely connected with the above study as it also explored the relationship between the two variables of interest, the exception is that the above study only focused on oil as the only commodity whereas in this study the researcher includes a group of commodities. Furthermore, it is similar in a sense that the formulated hypothesis is the same as they test if oil exerts a non-linear impact on the real exchange rates (Dauvin, 2014).

To achieve the objectives mentioned above, Dauvin (2014), made use of yearly data from 1980 to 2011 for two sets of countries, 10 energy exporting and 23 commodities exporting. To assess the connection between energy prices and the real exchange rate, the researcher adopted a refined version of the behavioral equilibrium exchange rate called the "stock flow approach to the equilibrium exchange rate" (Dauvin, 2014). In this approach, the long-term drivers of the real exchange rate are variables such as the Net Foreign Asset position, the Balassa Samuelson Effect and the Terms of Trade. Results from the panel unit root and co-integration test showed that all these variables impact the real exchange rate positively (Dauvin, 2014). Therefore, since the long run elasticity of the real effective exchange rate to the terms of trade is positive and significant, the currencies of all the energy dependent countries are regarded as energy currencies. Further the results from the panel nonlinear smooth transition regression model indicated that there is a certain threshold beyond which the real exchange rate responds to oil prices with effect from the terms of trade (Dauvin, 2014).

Since this study is for a single country, it is also worth reviewing single country studies which are in line with the analysis of this study. Khomo and Aziakpono (2007) used the Behavioral Equilibrium Exchange Rate method to estimate the equilibrium real effective exchange rate of the rand and establish whether the observed exchange rate is misaligned from this equilibrium level. The exchange rate's misalignment behavior is further explored using a regime switching model. Results confirm the existence of a cointegrating relationship between the real effective exchange rate and terms of trade, external openness, capital flows and government expenditure. The study confirms that the exchange rate is misaligned from time to time with the Markov regime switching model correctly capturing the misalignment as alternative shifts between overvaluation and undervaluation episodes.

Concerning studies that are specific to South Africa, Aron *et al.* (1997) is credited with pioneering the modelling of the rand's long-run equilibrium real exchange rate. Using quarterly data from 1970 to 1995, the scholars employ cointegration and error correction methodology to model the long-run and short-run determinants of the real exchange rate within the macroeconomic balance approach. The study concludes that the exchange rate is a function of variables like trade policy, terms of trade, capital flows, technology, official reserves and government expenditure. Aron *et al.* (1997) discovered that the real exchange rate evolves and fluctuates over time to reflect changes in several economic fundamentals and other shocks to the system. With regards to observed exchange rate misalignment episodes, their study reveals that it would require 0.85 years to eliminate 50% of a misalignment in the exchange rate.

Using the Johansen cointegration methodology, MacDonald and Ricci (2003) estimated the equilibrium real exchange rate for South Africa. From this methodology, they discovered that, most of the changes in the real exchange rate of South Africa can be explained by the real interest rate differential, Balassa Samuelson, commodity prices, trade openness, fiscal balance, and net foreign assets. Based on these fundamentals, the real exchange rate in early 2002, was found to be significantly more depreciated with respect to the estimated equilibrium level. The half-life of the real exchange rate from the estimated equilibrium was found to be 2 years. This study is central to the analysis of this thesis as it follows a similar approach to examining the behavior of real effective exchange rate in South Africa.

Taken together, the results of these studies reveal that there exists a link between energy price and the real exchange rates of different countries including South Africa. Countries are either taken individually or as a group that possesses similar characteristics. However, panel studies seem to provide ambiguous results for each country, hence it is highly recommended that countries be studied individually. This is because, countries compete in different markets and possess different characteristics which may lead to it being more vulnerable in some instance and not in other instances.

IV. AN EMPIRICAL MODEL OF THE REAL EFFECTIVE EXCHANGE RATE

Literature is rich with various functional forms used to estimate the relationship between energy prices and real exchange rates. The design of each of these empirical studies has been determined by the parameters of interest that researchers wished to estimate, and most importantly, data availability and suitable estimation techniques. However, in the number of studies consulted for this analysis, many of them failed to find support for the Purchasing Power Parity Hypothesis (PPP). These include studies by Roll (1979), Mishkin (1984), Pigott and Sweeney (1985), Bryant *et al*. (2005) and Cushman (2008). Even though this was the case, other researchers such as Meese and Rogoff (1983), Lane and Milesi- Firretti (2004) and Frankel (2007), reached an agreement that exchange rates have long run determinants. These determinants include variables such as, terms of trade, Balassa Samuelson, net foreign assets, trade openness, fiscal balance and the real interest rate. It is documented that there is a long run cointegrating relationship between these variables and the real exchange rate.

The failure in finding evidence for the PPP hypothesis, simply suggests that real exchange rates are influenced by different variables in the long run; they cause movements on the real exchange rates so much so that they deviate from their long run equilibrium value and prevent them from going back. This is thus proof that the long run PPP hypothesis does not hold. Other variables have been shown to influence the real exchange rate, as identified by literature. Therefore, this study will follow on the foot-steps of these studies to make adequate analysis of the link between real exchange rates and energy prices in South Africa.

To do this, this study will adopt an econometric specification referred to as the stock flow approach which is a refined version of the Behavioral Equilibrium Exchange Rate approach (BEER), proposed by Alberola *et al.* (1999). As per this approach, a set of explanatory variables such as the productivity differential also called Balassa Samuelson, net foreign asset position, terms of trade, trade openness, fiscal balance and the real interest rate are long term drivers of real exchange rates. The model specification is given by the equation below.

$$LNREER = a_t + \beta LNTOT + \beta LNBS + \beta NFA + \beta TO + \beta FB + \beta RIR + \mu_t \quad \ldots 5$$

where LNREER, is the log of real effective exchange rates, a_t is the intercept or drift term, β is the coefficient on all the explanatory variables, which stands to capture the impact of these in the regression analysis. The variables are LNTOT, the log of terms of trade, LNBS, the log of sectoral productivity, NFA, the net foreign asset position, TO, trade openness, FB, fiscal balance and RIR, the real interest rate. Finally, μ_t is the error term. Note that, all variables are expressed in logarithmic form except for NFA, TO, FB, RIR which are already expressed in percentage form.

a. Cointegration Techniques

- **The Engle and Granger Methodology.**

After having tested the stationarity properties of these variables, the Engle and Granger approach (1991) involves the use of OLS to estimate a long run equation given by equation 1 above. Further, from the above regression we obtain residuals and use unit root tests to test for the presence of unit root in the residuals given by the following equation:

$$\Delta\mu_t = \rho\mu_{t-1} \sum_{i=1}^{q} \delta_1 \Delta M_{t-p+1} + v_t \quad \ldots 6$$

We test the null hypothesis that the residuals have a unit root against the alternative that they do not have unit root. A set of critical values as provided by Engle and Granger (1991), is used to determine the rejection region. If the null hypothesis is rejected at a certain level of significance, this implies that the obtained residuals are stationary and therefore, confirming the existence of a long run relationship between the variables of interest. This follows several steps as shown below (Engle and Granger, 1991).

- **The Johansen Co-integration Methodology**

The superior test of co-integration is Johansen's test, because it possesses all the required statistical properties. However, this test also has weaknesses, one of which is that it relies on asymptotic properties, and is sensitive to specification errors in limited samples. Starting with a VAR representation of variables, where we have a p-dimensional process, integrated of order d, with the VAR representation, as follows:

$$A_k(L)x_t = \mu_0 + \psi D_t + \varepsilon_t \quad \ldots 7$$

To make the VAR a white noise process, it is formulated with lags and dummy variables. The demand for a well specified model are higher than for an ARIMA model (Khomo and Aziakpono, 2007). Here, the components in the residual process are not tested for, reason being, the critical values are determined conditionally on a normal distribution of the residual process. The system is assumed to be integrated of order one. By using the difference operator, the VAR in levels can then be transformed to a Vector Error Correction Model (VECM), given by the following equation:

$$\Delta x_t = \mu_0 + \Gamma_1 \Delta x_{t-1} + \cdots + \Gamma_{k-1} \Delta x_{t-k-1} + \prod x_{t-1} + \psi D_t + \varepsilon_t \quad \ldots 8$$

where Γ_i ε and Π are matrices of variables. The lag length on the VAR is k lags for each variable. After transforming the model to a VECM, we lose on lags, leading to k-1 lags in the VECM model. Hence, it becomes,

$$\Delta x_t = \mu_0 + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-1} + \prod x_{t-1} + \psi D_t + \varepsilon_t \quad \ldots 9$$

Where x_t is a vector of the log of all the variables included in the model. μ_0 is the intercept, ε_t is a vector of white noise process. Γ_i denotes matrix of coefficients containing information on the short run relationships among variables. The Π matrix conveys the long run information contained in the data. If the rank of Π is r, then Π can be decomposed into two n x r matrices α and β, such that β is the matrix of co-integrating vectors and α is the speed of adjustment parameter. This test calculates two statistics, the trace and the maximum Eigen; the null hypotheses are that there are at most r co-integrating vectors against the alternative that there are greater than r co-integrating vectors, this is given by the trace statistic. The Eigen value on the other hand would test for r co-integrating vectors against the alternative of $r + 1$ co-integrating vectors (Johansen, 1995).

b. Long-run coefficient estimation techniques

The long run relationship coefficients are obtained by employing the Dynamic Ordinary Least Squares (DOLS) method of estimation, shown below as:

$$y_t = \beta_0 + \sum_{i=1}^{n} \beta_n X_t + \sum_{i=1}^{n} . \sum_{j=-kb}^{kl} Y_t \Delta X_{t-j} + \varepsilon_t \quad \ldots 10$$

where kl and kb are leads and lags, respectively.

This is a simple approach in constructing an asymptotically efficient estimator, which gets rid of the feedback in the co-integrating system, advocated by Saikkonen (1992) and Stock and Watson (1993). The method involves augmenting the co-integrating regression with lags and leads of ΔX_t so that the resulting co-integrating equation error term is orthogonal to the entire history of the stochastic regressors innovations.

We expect the results from this method to be more accurate than that of orthodox OLS because the latter produces biased estimates and standard normal distribution depends on nuisance parameters, hence DOLS is preferable. A further advantage of DOLS is in its computing convenience (Khomo and Aziakpono, 2007).

c. Variable selection

The real effective exchange rates (LNREER): the real effective exchange rate of South Africa is calculated as the nominal effective exchange rate. This is a measure of the value of the currency against a weighted average of several foreign currencies divided by a price deflator or index of cost (Pineda *et al*., 2009). The data for this variable is obtained from the International Monetary Fund's (IMF) World Development Indicators (WDIs). This serve as the dependent variable in this analysis.

The net foreign asset position (NFA): many researchers, such as Lane and Milesi-Firretti (2004) have documented that the net foreign asset position of a country is one of the major important determinants of the real exchange rate of that country. This study therefore, employs the current account deficit/ surplus as a percentage of GDP, as a proxy for NFA. An appreciation of the current account deficit would require a country to borrow to finance the deficit. Therefore, this would have a negative effect on the country's NFA position. This is the reason for the equivalence of the current account balance and the NFA. This variable is expected to have a positive or a negative effect on the country's real exchange rate against trading partners. The data for this variable is obtained from IMF, Balance of Payments Statistics Yearbook and data files, and the World Bank and OECD GDP estimates (Dauvin 2014).

The real interest rates (RIR): several authors have documented that the real interest rate only has transitory effects on the real exchange rate. These include Dauvin (2014), McDonald and Ricci (2014) and Khomo and Aziakpono (2007). If it is the case that the domestic interest rate is above the world interest rate, this would mean that the country would experience large capital inflows. This would then lead to an appreciation of the domestic currency relative to trading partners. Thus, the expectation is a negative sign on the coefficient of this variable. The data for this variable is obtained from the IMF, International Financial Statistics, and the data files using World Bank data on GDP Deflator.

The terms of trade (LNTOT): are calculated by dividing both coal and oil prices of South Africa, by the manufacturing unit value index (MUV), where, MUV index is a measure of the prices of the developing country imports of manufactures in U.S. dollar terms. Therefore, an appreciation of the terms of trade means that, there would be an improvement on the real exchange rate of a country in question. This study utilizes a method proposed by Dauvin (2014) to calculate the value of energy terms trade, as per the following formula:

$$LNTOT = \left\{ \frac{coal\ prices^{\alpha} x\ oil\ prices^{\beta}}{MUV} \right\} \quad \ldots 11$$

where alpha is the share of coal prices on total exports and beta is the share of oil prices on total imports of South Africa. The data for crude oil is obtained from the World Bank commodity price data pink sheet (2016). The MUV data is obtained from the World Bank Database (2014). Finally, since data for coal prices were missing for South Africa, I used the Australian coal price data as a proxy for the South African coal price data. Among other reasons is the fact that over time the prices of coal for the two countries have been co-trending and evidence has shown that they do not diverge too far away from each other (Dauvin, 2014). This is depicted by a graphical representation, shown in appendix A of this thesis. This Australian coal price data is obtained from the World Bank commodity price data pink sheet (February 2016).

The Balassa Samuelson (LNBS): this shows the log of Balassa Samuelson, which is normally referred to as sectoral productivity in literature. The Balassa Samuelson is normally calculated by taking the GDP per capita of a domestic country based on PPP, divide it by that of its trading partner as per the following formula:

$$LNBS = \frac{GDP\ PC\ PPP_{SA}}{GDP\ PC\ PPP_{US}} \quad \ldots 12$$

where GDP per capita is, total GDP divided by the population, and GDP is the sum of gross value added by all resident producers in the economy, plus any product taxes minus any subsidies not included in the value of the product. However, since the data on GDP per capita based on PPP are only available towards the end of the period under consideration in South Africa, the study utilizes GDP per capita for SA divided by the GDP per capita for US, to calculate this variable, as per the following formula:

$$LNBS = \frac{GDP\ PC_{SA}}{GDP\ PC_{US}} \quad \ldots 13$$

The data on GDP per capita for both the countries are obtained from the World Bank national accounts data, and OECD national accounts data files.

The trade openness (TO): trade openness is the sum of exports and imports of goods and services measured as a share of GDP, therefore, a reason for this variable not to be logged. Trade restrictions would normally raise the price of domestic goods, hence resulting in inflation. As the rate of inflation increases relative to trading partners, so too is the real effective exchange rate of that country. The data for this variable is obtained from the World Bank national accounts data, and the OECD national accounts data files (MacDonald and Ricci, 2004).

The fiscal balance (FB): the cash surplus or deficit is state revenue (inclusive of grants) minus expenses and net acquisition of non-financial assets. An improvement in the fiscal position of a country means that more funds are flowing to the public sector in that country. Thus, a reallocation of resources from the private sector results in a decline in domestic demand, therefore further leading to reduced domestic prices. It is this price effect that leads to a depreciation in the real effective exchange rate (MacDonald and Ricci, 2003). The data for this variable are obtained from the IMF government financial statistics yearbook and data files, the World Bank and the OECD GDP estimates. This variable is not logged as it is already expressed as a percentage of GDP.

V. EMPIRICAL RESULTS

a. Unit Root Tests

Table 1: Unit root test results summary at level

Results in Level form				
Test Type	**Variables**	**Trend and intercept**	**Intercept**	**No intercept no trend**
	lnREER	-4.104611 [0.0123]	-1.424755 [0.5616]	-1.475242 [0.1293]

ADF	***lnTOT***	-3.231269 [0.0920]	-3.199323 [0.0269]	0.430603 [0.8026]
	lnBS	-0.284200 [0.9885]	-1.615996 [0.4659]	1.308160 [0.9495]
	NFA	-3.197060 [0.0982]	-3.028690 [0.0399]	-2.862252 [0.0052]
	TO	-2.000419 [0.5849]	-1.860192 [0.3475]	0.301404 [0.7685]
	FB	-2.623757 [0.2723]	-2.400525 [0.1474]	-1.619341 [0.0986]
	RIR	-3.854734 [0.0227]	-3.266031 [0.0227]	-2.742006 [0.0072]
PP	***lnREER***	-3.117638 [0.1150]	-1.192326 [0.6695]	-2.619795 [0.0100]
	lnTOT	-2.912664 [0.1686]	-2.721764 [0.0785]	0.412110 [0.7979]
	lnBS	-0.028848 [0.9946]	-1.577586 [0.4854]	1.910962 [0.9853]
	NFA	-2.875040 [0.1801]	-2.824332 [0.0631]	-2.655244 [0.0091]
	TO	-1.909564 [0.6327]	-1.749777 [0.3999]	0.73939 [0.8706]
	FB	-2.552701 [0.3028]	-2.259764 [0.1892]	-1.489984 [0.1259]
	RIR	-3.909009 [0.0199]	-3.242252 [0.0241]	-2.654964 [0.0091]
Notes: *P*-values in parentheses.				

Source: ***Authors own estimates***

Table 1 above shows a summary of results of each test for all the variables at level. Per the ADF test, real effective exchange rates have a unit root at all conventional levels (1%, 5%, 10%). The PP test confirms this, since we fail to reject the null hypothesis that real effective exchange rates have a unit root at all levels of significance. Evidence of exchange rates being non-stationary was provided by authors such as Amano and van Norden (1995, 1998) and Macdonald (1995). This led to the rejection of the Purchasing Power Parity hypothesis (PPP). Therefore, the above findings are in line with previous empirical findings and contradict Breuer (2001) who found in his analysis, evidence for the PPP hypothesis.

Taken together, the results of the PP test are generally in line with that of the ADF test, where most of the variables except particularly the interest rate and the net foreign asset position, were found to be non-stationary at the usual levels of significance. Simply put, the results indicate that we fail to reject the null hypothesis at a 1%, 5% and 10% levels of significance for LNREER, LNTOT, LNBS, TO and FB. Therefore, this indicate that all these variables are non-stationary or have a unit root. The second unit root results are also in agreement for the two test as shown in the appendix section of this research.

The following section will provide interpretation of the cointegration results, per the Engle and Granger (EG) methodology and the Johansen Cointegration methodology.

b. Engle and Granger Methodology (EG)

$$LNREER = \underset{[0.0000]}{6.342823} - \underset{[0.0025]}{0.143866}LNTOT + \underset{[0.0000]}{0.863026}LNBS - \underset{[0.0015]}{0.013577}NFA$$

$$- \underset{[0.0000]}{0.012220}TO + \underset{[0.0122]}{0.010465}FB - \underset{[0.1297]}{0.004602}RIR \quad \ldots 14$$

To determine the order of integration, I conduct a unit root test on the residuals obtained in the above long run equation, which shows the long run effect of the different explanatory variables on the real effective exchange rate. Further, these residuals can be then lagged once and incorporated in the Error Correction Model (ECM), which will help determine the speed of adjustment to long run equilibrium values. This test the hypotheses:

H_0: the residuals ($\hat{e}_t$) have a unit root (Non-stationary).

H_1: The residuals ($\hat{e}_t$) have no unit root (Stationary).

In testing for unit root in the residuals, I used the critical values provided by Engle and Yoo (1991) and MacKinnon *et al*. (1991), instead of the ones provided by Dickey and Fuller (1979). The unit root test results are displayed in Table 2 below.

Table 2: Residual unit root tests

Results in Level form	
Test Type	**Residuals**
Unit Root Test	-4.918750 [0.0000]
Notes: *P*-values in parentheses.	

Source: Authors own estimates

Using a sample size of 50 and 5 variables, the critical values at 1%, 5% and 10% levels of significance are -5.416, -4.700 and -4.348 respectively. Since the unit root test statistic is -4.918750, we reject the null hypothesis of unit root at a 5% and 10% levels of significance, and conclude that the residuals have no unit root, therefore they are stationary. What this tell us, is that there is co-integration within our variables of interest, meaning that, the log of real effective exchange rate, log of terms of trade, log of Balassa Samuelson, net foreign asset position, trade openness, fiscal balance and the interest rates, have a long run relationship.

$$\Delta LNREER = 0.000514 - 0.050932\Delta DLNTOT + 1.012844\Delta DLNBS - 0.014410\Delta DNFA$$

[0.9603] [0.4849] [0.0109] [0.0094]

$$-0.009866\Delta DTO + 0.005749\Delta DFB - 0.005234\Delta DRIR - 0.877860\, e(t\text{-}1)$$

[0.0000] [0.2480] [0.0688] [0.0000] …15

Short run equation, P-Values in parentheses

From the above equation, all the variables have the expected signs and are significant at a 5% and 10% levels of significance (except fiscal balance, which is insignificant). Now on the variable of interest which is the terms of trade, the above results suggest that a 1% increase in the terms of trade will result in a 0.05% decrease in the real effective exchange rate *ceteris paribus*. This variable has the expected sign however, it is insignificant at all levels suggesting that the terms of trade does not explain changes in the real effective exchange rate in the short run. We note that the direction of the effect of the variables is the same in the long run and short run, however, only the magnitudes differ.

After estimation of the short run equation as shown above, the coefficient on $e_{(t-1)}$ is found to be -0.877860. This means that, the system corrects its previous disequilibrium at a speed of 87.79% annually. Therefore, it takes approximately a year and a half for the real effective exchange rate to return to its equilibrium value in the short run, indicating that the speed of adjustment is quick. Moreover, the sign of the coefficient on the error term is negative and significant at all conventional levels, this indicates the validity of the long run equilibrium relationship between real exchange rates and its fundamentals.

c. The Johansen Cointegration test (VAR)

Table 3: Johansen co-integration test

Sample (adjusted): 1972 2014

Included observations: 43 after adjustments

Trend assumption: Linear deterministic trend

Series: LNREER LNTOT LNBS NFA TO FB RIR

Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

		Trace test		**Maximum Eigen Value Test**	
Hypothesized no. of CE(s)	**Eigenvalue**	**Trace statistic**	**0.05 Critical value**	**Max-Eigen Statistic**	**0.05 Critical Value**
None	0.751843	163.8785	125.6154	59.92878	46.23142
At most 1	0.499284	103.9497	95.75366	29.74378	40.07757
At most 2	0.490217	74.20589	69.81889	28.97208	33.87687
At most 3	0.299614	45.23381	47.85613	15.31329	27.58434
At most 4	0.259240	29.92052	29.79707	12.90338	21.13162
At most 5	0.250837	17.01714	15.49471	12.41835	14.26460
At most 6	0.101428	4.598789	3.841466	4.598789	3.841466

Source: Authors own estimates

The results above show that the trace and the maximum Eigen value tests endorse the existence of at least one co-integrating relationship amongst the variables. This indicates the rejection of the null hypotheses of no co-integration at a 5% level of significance. This confirms that in the long run, the real effective exchange rate moves together with the terms of trade, Balassa Samuelson, trade openness, fiscal balance, real interest rate and the net foreign asset position

Having established that there is co-integration between the variables of interest, the next step is to estimate a Vector Error Correction Model. Since this study is particularly interested in the estimation of a unique long run co-integrating relationship for the real effective exchange rate, not much emphasis is placed on the short run dynamics of the equation (Khomo and Aziakpono, 2007). Therefore, the VAR component of the VECM will not be constrained so to allow for the utilization of the full data set. The coefficients obtained from the above model can then be used to compute the equilibrium real effective exchange rate. Another feature of the methodology is to estimate the speed of adjustment, which is the speed at which the real effective exchange rate converges to its equilibrium level should there be an exogenous shock that places the system out of equilibrium. The results of the VECM are shown in Table 4 in the appendix, below is the equation representing these results.

$$LNREER = 7.14 - 0.13LNTOT + 1.41LNBS - 0.01NFA - 0.01TO - 0.01FB + 0.02RIR$$

(0.00341) (0.03551) (0.06059) (0.00331) (0.00112) (0.00302) (0.00341) …16

Source: authors' own estimates

Note: Standard errors in parentheses

The results from the vector error correction model estimates (see appendix) have the correct signs and all appear within reasonable expectations. From this, it is important to note the error correction factor of the co-integrating equation. Once a gap between the real exchange rate and its estimated equilibrium level develops (for whatever reason), the real exchange rate will tend to converge back to its equilibrium level over the longer term. Depending on the extent of the misalignment, this error correction factor ensures that the real exchange rate moves progressively towards the defined equilibrium level. The results of the model show that the speed of the error correction term is statistically significant and has the predicted negative sign with a value of -0.202193. This adjustment coefficient means that 20.22% of the previous period disequilibrium is corrected in each year.

I then performed a residual serial correlation test including lag length of 2 (see table in the appendix). The null hypothesis is that of no serial correlation against the alternative of serial correlation. From the results obtained we fail to reject the null hypothesis of no serial correlation at a 5% level of significance and hence conclude that there is no serial correlation amongst the lags included in the model. Having identified that there is co-integration among the variables of interest and the confirmation that the real exchange rate is endogenous in the model, a single equation model is then used to estimate the co-integration relationship (Khomo and Aziakpono, 2007). This single equation model equation is referred to as Dynamic Ordinary Least Squares as laid out in the previous chapter. The results from this model are discussed in the following section.

d. Long run estimation results

Table 4: Dynamic Ordinary Least Squares Estimates

Dynamic OLS Regression, dependent variable LNREER				
Variable Name	**Coefficient**	**Standard Error**	**t-statistic**	**p-values**
LNTOT	-0.211704	0.068437	-3.093439	0.0066
LNBS	1.231097	0.135140	9.109796	0.0000
NFA	-0.015900	0.006650	-2.390945	0.0286
TO	-0.010641	0.001454	-7.320477	0.0000
FB	-0.003285	0.005314	-0.618292	0.5446
RIR	0.010789	0.007294	1.479143	0.1574
R-Squared: 0.988488 Standard Error of regression: 0.039454				

Source***: authors own estimates***

First and foremost, the model appears to be able to explain a larger amount of variation in the dependent variable, i.e. it explains 98.85% of the variation in the real effective exchange rate. Further, the standard errors are quite low for all the variables, thus positing the efficiency of the method used. This is further shown by the standard error of the regression which proves also to be quite low. Hence, DOLS appears to be an efficient method in this analysis.

An appreciation of the domestic price level means that it is now expensive to purchase domestically produced goods and services relative to foreign goods and services. The resulting effect of this is less exports of domestically produced goods and services relative to foreign produced goods and services, hence resulting in less demand for foreign currency leading to depreciation of the value of domestic currency, while assuming no shipping costs.

DOLS suggest that a 10% improvement in the terms of trade leads to a 2.12% depreciation in the real effective exchange rates, *ceteris paribus*. This is significant at all conventional levels, meaning that terms of trade explain changes in the real effective exchange rates in the long run. This is in line with work by Amano and van Norden (1995), which found that an increase in in oil prices led to a depreciation of the exchange rates in Canada. This was due to the fact that the Canadian energy sector is highly regulated in order to project domestic oil consumers from high prices and due to the costs, that are borne by sectors when energy price increases; this study finds this explanation valid for South Africa whose currency depreciates by 2.12% following a 10% appreciation in energy prices. However, currency depreciation can be preferred at times, if it is not excessive. This is because it attracts more exports since locally produced goods become cheaper relative to foreign produced goods, hence reducing unemployment in the long run in the domestic economy.

When a country's terms of trade improve, it indicates that for every unit of export that a country sells, it can purchase more units of goods that are imported. This means that an increase in the terms of trade may potentially create the implication of benefit, as a higher number of exports would need to have been sold to buy the given amount of imports. However, when a country's terms of trade worsen, it indicates that the country must export a greater number of units to purchase the same given number of imports, hence a case for the South African economy when its terms of trade appreciates.

A 10% improvement in the Balassa Samuelson (sectoral productivity) leads to a 12.31% improvement in the real effective exchange rate, ceteris paribus. This is significant at all conventional levels. This variable had an incorrectly predicted sign in the VAR model, whereas with the application of DOLS it has the expected sign and seem to explain much of the variations in the real effective exchange rate in the long run. This means that countries with high productivity growth also experience high wage growth, which leads to higher real exchange rates. The Balassa-Samuelson effect suggests that an increase in wages in the tradable goods sector of an emerging economy will also lead to higher wages in the non-tradable (service) sector of the economy. Since South Africa is a developing economy, as it develops and becomes more productive and realizes increased wages, it will also experience increases in both the tradable and non-tradable goods sectors of the economy. When wages increase at a slower rate than productivity, the country winds up producing more than it can consume. It will therefore have a current account surplus. When wages grow faster than the productivity rate, workers consume more goods and the current-account surplus falls (Dauvin, 2014).

Further, a 10% improvement in South Africa’s net foreign asset position, results in a decline of 0.16% in the real effective exchange rate, *ceteris paribus*. This variable is statistically significant at all conventional levels. Since a nation's Net Foreign Assets (NFA) position is defined as the cumulative change in its current account over time, the net foreign assets position indicates whether that nation is a net creditor or debtor to the rest of the world. A positive NFA balance means that it is a net lender, while a negative NFA balance shows that it is a net borrower. This means that for South Africa, when it is a net lender, the value of its currency will decline, and vice versa (Khomo and Aziakpono, 2007).

The above result may appear to be counter-intuitive, but occurs in this particular case because this study uses the real effective exchange rate instead of the real exchange rate. Economically, a positive relationship is expected between the net foreign asset of a country and its real exchange rate, but not necessarily so with the real effective exchange rate. The relationship between the net foreign asset position and the real effective exchange rate of a country can be positive or negative, since the real effective exchange rate is calculated incorporating several other countries’ exchange rates simultaneously.

Trade openness affects the long run equilibrium real effective exchange rate, such that a 10% improvement in trade openness leads to a 0.11% reduction in the real effective exchange rate, *ceteris paribus*. Moreover, an improvement of 10% in the fiscal balance depreciates the real effective exchange rate by 0.03%, *ceteris paribus*. However, this variable is insignificant in the model. Finally, the results suggest that a 10% increase in the real interest rate will induce a 0.11% increase in the real effective exchange rate. Again, this variable is insignificant at all levels of significance; therefore, we conclude that the real interest rate does not explain long run changes in the real effective exchange rate. This is a similar finding with other studies, such as that of Dauvin (2014), Khomo and Aziakpono (2007) and MacDonald and Ricci (2003).

Most of the variables in the above DOLS model have a negative impact on the real effective exchange rate of SA; therefore, they result in a depreciation of this variable. Thus, it remains important to note that exchange rate appreciation may not be favorable always. For example, if a country is open to foreign competition, appreciation of the domestic exchange rate makes locally produced goods more expensive relative to foreign produced goods. This in turn has negative effects on the manufacturing sector, and the country's competitiveness (Dauvin, 2014).

The above findings pose several implications for South Africa. Nominal energy prices have declined since mid-2014, thus the energy terms of trade are expected to decline. If this happens, the expectation is that the rand value of the country would decline as has been evidenced lately in the country. The study has also established that the two major energies in SA have opposing effects on the terms of trade, and when combined to calculate the terms of trade and examine the effect on the real exchange rate, the terms of trade have a negative effect on the real exchange rate. This might mean that since South Africa is importing most of its oil requirements relative to the amount of coal exported, oils exert a stronger downward force on the terms of trade so much so that it results in a negative effect on the value of the rand.

VI. Concluding remarks and policy implications

The application of the DOLS methodology suggests that there is a positive long-run equilibrium relationship between the real effective exchange rate and the Balassa Samuelson, and real interest rate. Therefore, an increase in the Balassa Samuelson or the interest rate would lead to an increase in the real effective exchange rate, *ceteris paribus*. Further, the results from the DOLS method suggested that there is a negative long-run equilibrium relationship between the real effective exchange rate and the net foreign asset position, trade openness and the fiscal balance. Therefore, an increase in the net foreign asset or trade openness or fiscal balance would result in a decline the real effective exchange rate, *ceteris paribus*. Lastly, on the main variable of interest *viz*. the terms of trade, the results suggested that there is a negative long-run equilibrium relationship between the real effective exchange rate and the terms of trade. Hence, an increase in the terms of trade would results in a decrease in the real effective exchange rate, *ceteris paribus*.

Given the recent fluctuations in the South African rand, this study possesses important implications for the country, as it relies heavily on imports and exports for the generation of revenue. We have noted that changes in the terms of trade lead to changes in the real effective exchange rate. Therefore, to prevent changes in energy prices from exacerbating the problem of macroeconomic instability, the country should find a way to safeguard the impact of high variability of energy prices, perhaps through the constitution of a "Sovereign Wealth Fund" or nominal exchange rate adjustments (Dauvin, 2014).

In terms of future research, research aiming at better understanding the relationship between energy prices and the real effective exchange rate through the terms of trade channel, should be able to provide guidelines on how to reduce the dependence on energy prices since coal and crude oil affect both the country's imports and exports. It should be noted that Dauvin (2014) found, in his panel study, that the rand is an energy currency, and when the country is studied in isolation, as in this study, the results are also in agreement with what was found by the author. However, this may not be the case for all countries, therefore, it is recommended that country-specific studies be undertaken, because the environments they operate in are different and the results might therefore become biased when aggregated with the data from other countries.

VII. References

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VIII. Appendices

A. COINTEGRATION TESTS

Table B1: Long run equilibrium relationship

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNTOT	-0.143866	0.044504	-3.232670	0.0025
LNBS	0.863026	0.058846	14.66585	0.0000
NFA	-0.013577	0.003967	-3.422634	0.0015
TO	-0.012220	0.001484	-8.232460	0.0000
FB	0.010465	0.003974	2.633026	0.0122
RIR	-0.004602	0.002971	-1.548709	0.1297
C	6.342823	0.208710	30.39063	0.0000

R-squared	0.948461	Mean dependent var	4.750356
Adjusted R-squared	0.940323	S.D. dependent var	0.256031
S.E. of regression	0.062545	Akaike info criterion	-2.563818
Sum squared resid	0.148652	Schwarz criterion	-2.282782

Log likelihood	64.68591	Hannan-Quinn criter.	-2.459051
F-statistic	116.5510	Durbin-Watson stat	1.358794
Prob(F-statistic)	0.000000		

Table B2: Unit root test on the residuals of the long run equation

Null Hypothesis: RESID02 has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.918750	0.0000
Test critical values:	1% level	-2.619851	
	5% level	-1.948686	
	10% level	-1.612036	

*MacKinnon (1996) one-sided p-values.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID02(-1)	-0.935209	0.190131	-4.918750	0.0000
D(RESID02(-1))	0.315718	0.156165	2.021699	0.0498

R-squared	0.386244	Mean dependent var	-0.002571
Adjusted R-squared	0.371274	S.D. dependent var	0.069102
S.E. of regression	0.054793	Akaike info criterion	-2.925122
Sum squared resid	0.123092	Schwarz criterion	-2.843206
Log likelihood	64.89013	Hannan-Quinn criter.	-2.894914
Durbin-Watson stat	1.948726		

Table B3: Error Correction model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLNTOT	-0.050932	0.072163	-0.705798	0.4849
DLNBS	1.012844	0.377040	2.686300	0.0109
DNFA	-0.014410	0.005249	-2.745050	0.0094
DTO	-0.009866	0.002082	-4.739264	0.0000
DFB	0.005749	0.004896	1.174337	0.2480
DRIR	-0.005234	0.002791	-1.875646	0.0688
UT	-0.877860	0.180424	-4.865533	0.0000
C	0.000514	0.010269	0.050075	0.9603

R-squared	0.683787	Mean dependent var	-0.019660
Adjusted R-squared	0.622301	S.D. dependent var	0.093141
S.E. of regression	0.057242	Akaike info criterion	-2.720087
Sum squared resid	0.117960	Schwarz criterion	-2.395689
Log likelihood	67.84192	Hannan-Quinn criter.	-2.599785
F-statistic	11.12106	Durbin-Watson stat	1.573872
Prob(F-statistic)	0.000000		

B. VECTOR AUTOREGRESSIVE

Table C1: The Johansen Cointegration method

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.751843	163.8785	125.6154	0.0000
At most 1 *	0.499284	103.9497	95.75366	0.0121
At most 2 *	0.490217	74.20589	69.81889	0.0214
At most 3	0.299614	45.23381	47.85613	0.0864
At most 4 *	0.259240	29.92052	29.79707	0.0484
At most 5 *	0.250837	17.01714	15.49471	0.0293
At most 6 *	0.101428	4.598789	3.841466	0.0320

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.751843	59.92878	46.23142	0.0010
At most 1	0.499284	29.74378	40.07757	0.4408
At most 2	0.490217	28.97208	33.87687	0.1722
At most 3	0.299614	15.31329	27.58434	0.7231
At most 4	0.259240	12.90338	21.13162	0.4611
At most 5	0.250837	12.41835	14.26460	0.0959
At most 6 *	0.101428	4.598789	3.841466	0.0320

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Table C2: Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-377.6831	NA	0.212921	18.31824	18.60785	18.42440
1	-149.1714	369.9714*	4.27e-05*	9.770065	12.08696*	10.61930*
2	-100.3604	62.75696	5.25e-05	9.779066	14.12324	11.37138
3	-45.47512	52.27169	7.07e-05	9.498815*	15.87027	11.83421

Table C3: VAR Residual Serial Correlation Test

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 11/03/16 Time: 23:28
Sample: 1970 2014
Included observations: 44

Lags	LM-Stat	Prob
1	55.61241	0.2399
2	42.93627	0.7162
3	33.95295	0.9497

Probs from chi-square with 49 df.

Table C4: Vector Error Correction Model

Cointegrating Eq:	CointEq1
LNREER(-1)	1.000000
LNTOT(-1)	0.133594
	(0.03551)
	[3.76200]
LNBS(-1)	-1.405622
	(0.06059)
	[-23.1986]
NFA(-1)	0.012273
	(0.00331)
	[3.70981]
TO(-1)	0.010971
	(0.00112)
	[9.76027]
FB(-1)	0.008270
	(0.00302)
	[2.73888]
RIR(-1)	-0.019350
	(0.00341)
	[-5.67260]
C	-7.139774

Error Correction:	D(LNREER)	D(LNTOT)	D(LNBS)	D(NFA)	D(TO)	D(FB)	D(RIR)
CointEq1	-0.202193	0.130461	0.255528	-16.88953	27.26812	-8.909960	2.018409
	(0.21101)	(0.31708)	(0.04379)	(4.95859)	(11.4411)	(4.74809)	(10.4655)
	[-0.95819]	[0.41145]	[5.83559]	[-3.40612]	[2.38335]	[-1.87654]	[0.19286]

Table C5: Serial Correlation Test on the VECM

Lags	LM-Stat	Prob
1	44.77399	0.6450

2	44.08034	0.6724

C. DYNAMIC ORDINARY LEAST SQUARES

Table D1: Long run Equilibrium Relationship

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNTOT	-0.211704	0.068437	-3.093439	0.0066
LNBS	1.231097	0.135140	9.109796	0.0000
NFA	-0.015900	0.006650	-2.390945	0.0286
TO	-0.010641	0.001454	-7.320477	0.0000
FB	-0.003285	0.005314	-0.618292	0.5446
RIR	0.010789	0.007294	1.479143	0.1574
C	6.581409	0.414190	15.88983	0.0000
R-squared	0.988488	Mean dependent var		4.738028
Adjusted R-squared	0.972236	S.D. dependent var		0.236781
S.E. of regression	0.039454	Sum squared resid		0.026463
Long-run variance	0.001200			