UNIVERSITY OF KWAZULU-NATAL

Energy currencies : the case of Sub-Saharan Africa

By

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CHAPTER ONE

INTRODUCTION

1.1. Background of the study

Exchange rates are deemed a vitally important tool to measure a country's attractiveness (Dauvin, 2014). Simply put, a strong exchange rate implies that locally produced goods are more expensive than goods produced overseas goods and vice versa. Exchange rates can be viewed from a nominal and real perspective. Whereas the real exchange rate is the "relative price of foreign produced goods and services to domestic produced goods and services, it is a measure of the quantity of the real GDP of other countries that a domestic country gets for a unit of its GDP", the nominal exchange "is the value of domestic currency expressed in terms of foreign currency per domestic currency, and it is a measure of how much one country's money exchanges for a unit of another currency" (Parkin *et al*, 2010: 575).

Whilst exchange rates are crucial in understanding a country's competitiveness, there is little agreement amongst economists and policy makers on what really determines the long-run equilibrium exchange rate (Meese and Rogoff, 1983). However, Meese and Rogoff (1983) point out that exchange rates do not evolve unpredictably; rather, they are determined by certain economic fundamentals. Scholars such as MacDonald (1995), Lane and Milesi-Ferretti (2004), and Frenkel (2007), amongst others, have studied the determinants of the exchange rate

The South African rand has experienced large movements in its value in past years (Frenkel, 2007) and other African currencies such as the Nigerian naira, and Angolan kwanga, among others may have also undergone vast changes. What accounts for these substantial movements? A number of studies have endeavored to answer this question, including Frenkel's (2007) investigation that focused on South Africa. A number of significant questions need to be considered in order to clarify the swings in these currencies, including the one posed by Frenkel (2007): Is the South African rand a commodity currency? This study includes both South Africa and other Sub-Saharan African countries such as Nigeria, Angola, Republic of Congo and Mozambique in its analysis.

Chen and Rogoff (2003, 2007) argue that when a country depends profoundly on exporting commodities, the value of its exchange rate is principally driven by the price of commodities.

A currency whose value is determined by the price of commodities is referred to as a ‘commodity currency’. Such countries include Australia, New Zealand, Canada, and South Africa (Macdonald and Ricci, 2003; Chen and Rogoff, 2003; and Frenkel 2007). If a currency is categorized as ‘commodity currency’, its currency appreciates when the country's terms of trade improve and depreciates when the terms of trade degrade (Chen and Rogoff, 2007). While there is a growing body of research on commodity currencies, no study has focused explicitly on Sub-Saharan African countries that are heavily dependent on commodity exports. For the reasons discussed below, their case might prove dissimilar from other countries as well as remarkable.

Having established that when countries depend intensely on commodity exports, their exchange rate is driven by commodity terms of trade, it is essential to note that some countries’ commodity exports are dominated by a solitary or specific commodity such as primary energy inputs, gold, or platinum. Canada, Nigeria, and the Middle-Eastern countries’ commodity exports are dominated by energy (Cashin and Patillo, 2006; IMF, 2014). A currency driven by energy prices is known as an ‘energy currency’ (Dauvin, 2014). Where this is the case, the price obtained for exports of energy carriers might make a noteworthy contribution to the movement of an energy exporting country's currency; hence, it is of value to examine the impact of energy prices in isolation from other commodities.

Amano and van Norden’s (1995) study advocated for the separation of the energy terms of trade from other commodity terms of trade. Failure to do so could result in imprecise reading of the bearing of energy terms of trade on the real exchange rate. Cashin and Patillo (2006) postulate that generally, terms of trade have and are becoming less interesting, particularly for developing countries (predominantly in Sub-Saharan Africa). Countries such as those in South East Asia have sanguinely diversified into exporting manufactured goods, while those in Sub-Saharan Africa have become ever more reliant on specific commodities. While general commodity terms of trade are a valuable pointer of movements in commodity prices, because the countries in question tend to export a large share of energy commodities, their terms of trade are more likely to be driven by energy prices.

Amano and van Norden (1995) argue that the energy terms of trade have a statistically noteworthy effect on the long-run real exchange rate when studied in isolation from other commodities. This is due to the instability of energy prices and the fact that such prices are determined on the international market. Hence, an individual country has little or no control over energy prices. Therefore, energy exporting and importing countries are susceptible to energy price shocks, particularly those that depend heavily on energy exports for revenue or on energy imports for growth. The impact of energy prices on the exchange rate is echoed in the energy terms of trade. An increase in the value of energy inputs on international markets should result in an improvement in the exporting country's terms of trade that then translates into an appreciation of the country's currency.

Following Hamilton's (1983) pioneering study that examined the connection between oil prices and the U.S. macro-economy, numerous studies have been conducted on the link between energy prices and the exchange rate. However, most empirical work in this field focuses on oil (Amano and van Norden, 1995; Issa *et al*, 2008). While a few studies have paid attention to energy input prices as a whole (Dauvin, 2014; Korhonen and Juurikkala, 2009), they did not examine Sub-Saharan African countries on their own. A study of this nature is deemed essential as many Sub-Saharan Africa countries are giants in the market for energy inputs, including Nigeria, which is the largest producer of oil in Africa and is among the world's top five exporters of liquefied natural gas (LNG), Angola, which is the second largest producer of oil in Sub-Saharan Africa after Nigeria, and South Africa, which supplies more than 25% of its coal production to the world (U.S. Energy Information Administration, 2014).

African countries are an exceptional and interesting case. While the Continent is endowed with natural resources, including primary energy carriers such as oil, coal and gas that are significant drivers of economic growth; these economies are experiencing slow economic development although growth rates are high (Sachs and Warner, 1997). As noted earlier, the exchange rate is extremely important for a country's competitiveness. Understanding the bearing of energy prices on the exchange rate would therefore be very helpful in policy-making decisions and would enable Africa to reap the benefits of her resources without suppressing the development of other economic sectors that in turn, affect the whole economy, in other words, evading the so-called 'resource curse', a notion that maintains that resource rich countries tend to perform more poorly in terms of economic development than resource deprived countries (Raymond and Mikesell, 1997).

This study therefore utilises fully-modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) econometric procedures to appraise the long-run elasticities of the real exchange rate for a selected set of Sub-Saharan African countries, to economic fundamentals, such as the energy terms of trade, the Balassa-Samuelson effect (B-S), the net foreign asset position (NFA) and the real interest rate.

This study is structured as follows. Chapter two reviews the relevant empirical literature, while chapter three discusses the methods used and data sources and also provides a concise explanation of the variables applied in this study. Chapter four presents and analyses the study's findings and chapter five offers concluding remarks and policy recommendations.

1.2. Rationale for the study and Problem statement

What has determined the value of energy exporting Sub-Saharan African currencies? Do energy prices matter for Sub-Saharan energy exporting countries? Do African currencies appreciate when energy prices increase or do they depreciate following a decrease in energy prices? This study seeks to investigate the relationship between exchange rate fundamentals such as energy terms of trade, sector wide productivity, net foreign asset position and real interest rate.

1.3. Aims and Objectives of the study

While there is mounting evidence of the presence of energy currencies in developed energy exporting countries, such as Canada (Amano and van Norden, 1995 and Issa et al. 2008 among others); Sub-Saharan African countries that are exporters of energy carriers have been neglected as a field of study. Meese and Rogoff (1983) argued that the real exchange rate is determined by certain economic fundamentals. Following their ground-breaking study and those by, among other scholars, Amano and van Norden, Dauvin (2014), Macdonald (1995) argued that exchange rate are determined by certain economic essentials; hence, they do not follow a random path and the purchasing power parity does not hold. Using a unit root test as was done by Oh (1996), the study examines if purchasing power parity holds. Should the null hypothesis be rejected, this will suggest that Meese and Rogoff were correct in their assertion that exchange rate do not follow a random path. Thus, other variables such as the NFA, Balassa-Samuelson and real interest rate impact on the real exchange rate. The objectives of the study are to determine:

- Whether the exchange rate of the selected Sub-Saharan African countries follows a random walk

The first objective will be achieved by testing the following hypothesis;

H_0: Purchasing Power Parity does not hold

H_1: Purchasing Power Parity holds

- Whether there are energy currencies in energy exporting Sub-Saharan African countries.

This objective will achieved by estimating the long-run exchange rate elasticities. If energy terms of trade significantly affect the exchange rate, this would mean that the null hypothesis cannot be rejected and hence, energy currencies do exist in energy exporting Sub-Saharan African countries.

H_0: Energy currencies exist

H_1: Energy currencies do not exist

- Whether there is causality between the exchange rate and economic fundamentals and, if so, in what direction the causality is running.
- The study's final objective is to offer recommendations to policy makers that will enable Sub-Saharan African countries to avoid the negative impact of economic shocks on their long-run exchange rate values.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

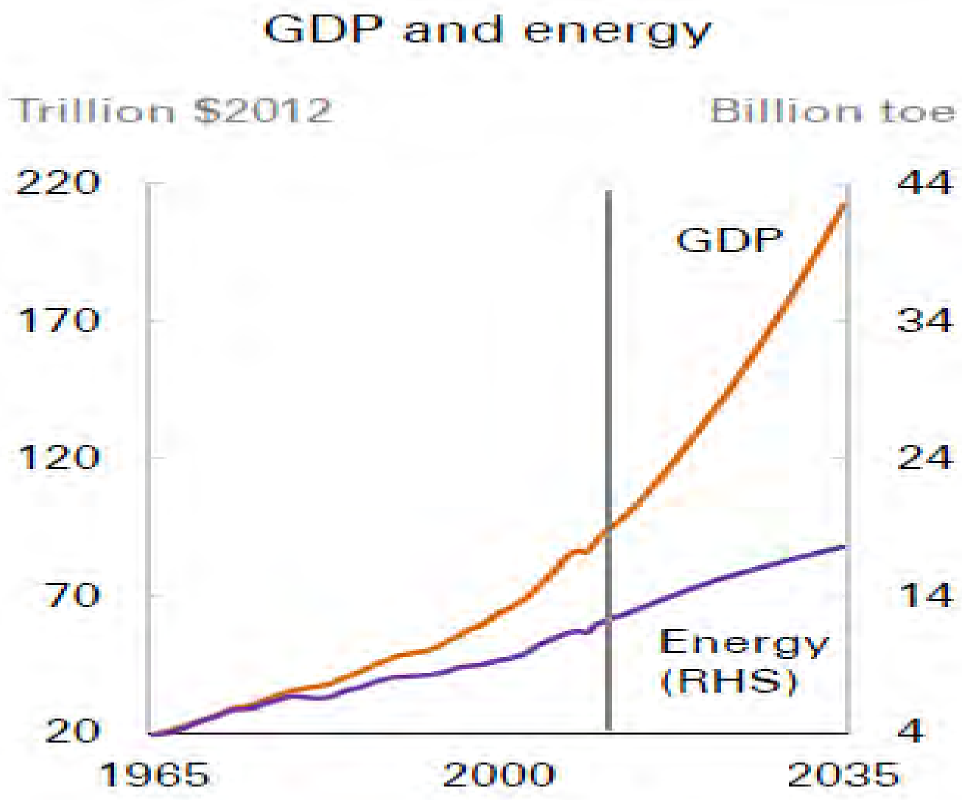
This chapter reviews the literature on developments and expected movements in energy markets, particularly with regard to the prices of energy inputs. It also reviews the theory behind the real exchange rate and the different models that have been used to offer insight into the determination of exchange rates. Furthermore, it presents a concise review of the empirical literature on the impact of the terms of trade on the long-run real exchange rate.

2.2.Trends in energy market developments and their impact on economies

This section examines the evolution of energy prices and the economic fundamentals employed in this study, such as net foreign asset position, real interest rates, exchange rates, and productivity.

The International Energy Agency (2014) estimates that the demand for oil alone is likely to increase by 35%-40% by 2030, while demand for other energy inputs is expected to increase by 41% by 2035 with 95% of the growth coming from emerging economies (BP Energy Outlook, 2014). The shift in demand for energy can be attributed to rising incomes and standards of living, China being a typical example of this phenomenon. As incomes and standards of living rise, demand for energy increases, causing prices to soar as supply grows less rapidly than demand, *ceteris paribus*. Figure 1 below shows the relationship between energy demand and GDP (income). As income increases, the demand for energy rises; however, for the global economy, the growth in GDP is more rapid than the demand for energy.

Figure: 1



[1]

Source: BP Energy Outlook (2014)

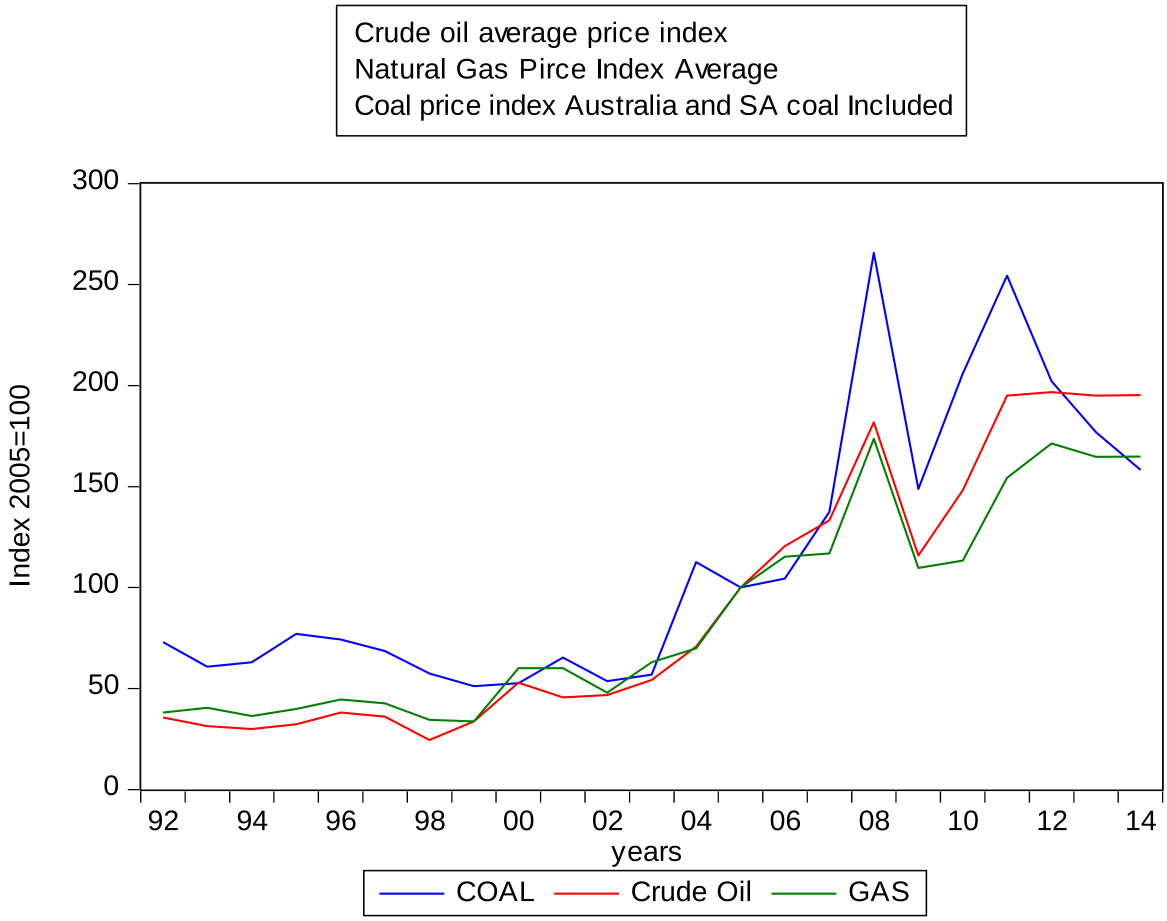
Rising demand for energy is largely driven by industrialization and electrification in some developing markets such as China and South Africa. On average, energy consumption increases by 1.5% per annum. This exerts pressure on the supply side and in turn translates to a rise in energy prices as producers try to keep up with the soaring demand for energy; this issue is clearly articulated in figure 2 which shows the trend in energy prices.

Despite the imposition of policies designed to discourage the demand for fossil fuels in order to meet greenhouse gas emission targets, the demand for energy has increased rather than declined since the early 1990s, the exception being the 2008 financial crisis which hit all sectors of the global economy. The decline in energy consumption and prices during 2008 is clearly illustrated in figure 2. In 1973 the demand or consumption of crude oil was 56.3% of total energy; this fell to 47.6% of total energy demand in 2012. However since the 1970s, crude oil has continued to be the most utilised source of energy. Natural gas demand was

[1] RHS on Figure 1 means Right Hand Side. GDP is measured starting from the left hand side to the right hand side and energy is measured from the (RHS) to the left hand side (LHS).

17.77% in 1973 and has been growing at a rate of 1.8% since the early 1990s (IEA, 2013), reaching 19.8% in 2012. While the demand for coal has been declining since the early 1970s at a rate of 0.2%, demand for coal declined from 10.8% in 1973 to 3.4% in 2013 (World Key Energy Statistics, 2014). These changes over time are reflected in the changes in the prices of energy input shown in figure 2. Figure 2 below shows that energy prices have been increasing since the early 1990s, fell in 2008 and rebounded in early 2009. Natural gas prices appear to be growing at a faster rate than other energy input prices due to growing demand for this source of energy.

Figure: 2 Trend in Energy Prices



Source: IMF World Economic Outlook Database

2.3. Theoretical background

2.3.1. Exchange Rate Definition

The exchange rate is the value of foreign currency in terms of the domestic currency. Exchange rates basically measure how many units a foreign currency can buy in the domestic economy (Heffernan and Sinclair, 1990).

The real exchange rate can be clearly analysed by the following equation;

$$P_i^* = E * P_i \dots \dots (1)$$

The equation shows what is generally recognized as the 'law of one price' that asserts that, if prices are transformed into a common currency, goods in a foreign country will cost the same price as in the domestic country. In the equation, E denotes the nominal exchange rate, namely, the price of foreign currency expressed in terms of domestic currency units. The P denotes the prices of a given good in the domestic and foreign country and the foreign country is signified by an asterisk..

Here, a rise in E indicates the appreciation of the exchange rate; one could argue that an increase in domestic prices leads to a depreciation of exchange rates via the current account relationship.

An increase in the internal price level means that home goods are more costly relative to external goods; thus exports shrink relative to imports, and the demand for foreign currency contracts and domestic currency depreciates. This is based on the assumption of no transaction or transportation costs, etc.

Equation 1 can be expressed in terms of relative competitiveness, that is, the real exchange rate, by simply dividing the right hand side (RHS, hereafter) of equation 1 by the left hand side (LHS) of equation 1, thus yielding equation 2.

$$RER = \frac{EP_i}{P_i^*} \dots \dots (2)$$

Equation 2 represents the real exchange rate. In equation 2 an increase in the real exchange rate (RER) on the LHS signals the appreciation of the real exchange rate. Simply put, a domestic basket of goods can purchase more of foreign basket of goods.

2.3.2. Monetarist/Asset Approach (MA) to Equilibrium Exchange Rates

Due to the lack of unanimity on the theory of the determination of exchange rates, some scholars have theorised that exchange rates are determined by conjecture and 'market psychology'. Simply put, this suggests that exchange rates are determined by the beliefs that agents hold about the foreign exchange market rather than economic fundamentals (Horne, 2004). Horne (2004) argues that there is no systematic connection between economic rudiments and the exchange rate and that the foreign exchange market is not well-organised; therefore, purchasing power parity (PPP) cannot hold. The monetary or asset approach arose out of the need for a model to examine the determinants of equilibrium exchange rates (Bilson, 1978 and Mussa, 1983).

What defines the value of *currencies*? Firstly, the current and potential currencies in motion are the core element of the worth of currencies. The second factor is the amount of purchasing power which society holds in the shape (Frankel, 1978).

The monetary approach rests on two main assumptions. The first is the presence of steady money demand and an open economy, while the second is that purchasing power parity holds (the price of a commodity in a country equals the price of the commodity in question in the foreign country).

The monetary approach can be formally shown by equation 3 below;

$$\frac{M}{P} = ke^{-\varepsilon i}y^{\rho} \dots\dots (3)$$

The LHS of equation 3 represents the real demand for money; e is the interest rate elasticity of money demand k, ε, ρ is parameters and i and y is nominal interest rates and real income respectively. This indicates that real money demand is an adverse function of interest rates and positively depends on real income. Money supply and real incomes are assumed to be given and variations in interest rates depend on changes in the expected rate of inflation (Bilson, 1978).

These assumptions imply that real interest rates are constant. The Fisher equation expresses real interest rates as; $RIR = i - \pi^e$. Thus, if real interest rates remain constant, any movement in the expected rate of inflation must be accompanied by equal movement in the nominal interest rates which in turn negatively affect real money demand.

The price level acts as a regulator; it adjusts to maintain and restore equilibrium in this model such that an upsurge in money supply must be accompanied by an approximate increase in the price level, thus keeping real money supply constant. Even though the asset approach focuses more on the concept of PPP, it does not classically tail the influence of the exchange rate through orthodox price indices, such as WPI, CPI and traded goods price indices.

The proportions of several quantities of goods in the different national indices may not be identical and the goods that are included in the respective indices may also not be identical as is clearly the case with non-traded goods. Therefore, foreign exchange rates have nothing to do with the WPI, CPI and other indices as such, but only with individual prices (for tradable goods) (Ohlin, 1967).

The fundamental reason why the asset approach ignores conventional price indices is that they are not an accurate indicator of market price. This has led to the correct price index being treated as an unobservable variable whose ratio for any two nations is given by exchange rates.

PPP is given by E=P/P*. The asterisk indicates that foreign variable, P's are simply price levels and E is the nominal bilateral exchange rate. Given the above information, equation 3 could be re-arranged to yield equation 4

$$\frac{EM*}{M} = \frac{k*}{k}\left[\frac{y*}{y}\right]^{\rho} e^{-\varepsilon(i*-i)} \ldots\ldots(4)$$

In equation 4, SM refers to foreign money demand expressed in terms of domestic currency and M is domestic money demand; hence, the LHS gives the relative money demand for two countries. The RHS of the equation shows the determinant of exchange rates or rather of the demand for money in both countries.

The equation for relative demand could be re-arranged further to express it in terms of exchange rates giving us equation 5 such that,

$$E = \frac{M*}{M}\left[\frac{y*}{y}\right]^{-\rho} \frac{k}{k*} e^{\varepsilon(i*-i)} \ldots\ldots(5)$$

From equation 5, is clear that an increase in the real income in the domestic country appreciates the home currency relative to the foreign currency and an upsurge in domestic interest rates depreciates the local currency. Suppose that people expect inflation to be higher in the next period, thus pushing nominal interest rates up, then the cost of holding money increases. Thus demand for the domestic currency will be reduced and it will depreciate. If this relationship does not hold in the empirical analysis, this means that the monetarist approach is not an accurate measure of exchange rate determinants (Bilson, 1978).

2.3.3. Exchange Rate-Fundamentals Nexus

This section derives exchange rates in a way that reveals the motivation for this study. It shows the link between real exchange rates and economic fundamentals, namely, the Balassa-Samuelson (sectoral productivity) effect and the country's terms of trade. Numerous studies have followed the two sector model in explaining these links (Neary, 1988; MacDonald, 1998; Chen and Rogoff, 2003; Coudert *et al,* 2008; and Dauvin, 2014).

Coudert *et al* (2008) used a two sector model to depict the relationship among the real exchange rate, terms of trade and productivity. This model assumes that a country only produces two types of goods, tradables and non-tradables. It is assumed that domestic agents do not consume the tradables produced in their home country; therefore, a change in the commodity price does not give rise to direct demand effects. All effects come from the supply-side.

It is also worth noting that tradables are subject to international competition; therefore, a country cannot influence the price as it is determined by global supply and demand (Neary, 1988; Chen and Rogoff, 2003; and Coudert *et al,* 2008). This suggests that the real exchange rate response will depend on the price elasticities of both demand and supply in non-traded sectors, as well as on the income elasticity of demand.

Furthermore this model assumes that labour is mobile across sectors; this assumption is closely linked to the Balassa-Samuelson effect. A wage increase in the tradable sector will force a wage increase in a non-tradable sector and this will spread across the entire economy, causing internal real exchange rates to appreciate.

Formally two sector models can be shown as follows;

$$P_n = \frac{a_x}{a_n} P_x \dots\dots (7)$$

P_n Denote the prices of non-tradables goods and price of tradable goods, respectively, a_x and a_n shows marginal productivity of labour in tradable and non-tradable sector respectively. Therefore, the consumer price index for domestic economy is given by;

$$CPI = P_N^{\theta} P_x^{1-\theta} \dots \dots (8)$$

The law of one price is assumed to hold such that,

$$P_x = \frac{P_x^*}{E} \dots \dots (9)$$

Similarly for the foreign economy the prices of non-tradable can be expressed as a function of tradable and relative productivities between tradable and non-tradable sector such that,

$$P_n = \frac{a_I^*}{a_N^*} P_I^* \dots \dots (9)$$

Therefore, the foreign consumer price index is given by;

$$P^* = (P_N^*)^{\theta} (P_T^*)^{1-\theta} \dots \dots (10)$$

It is now easy to show how real exchange rates are determined in the local economy. The real exchange rate is expressed as the price of foreign price of the domestic basket of consumption relative to the foreign price of foreign basket of consumption $\left(\frac{EP}{P*}\right)$. Therefore, by using equation 7-10 it can be shown that

$$RER = \left[\frac{A_X}{A_N} \frac{A*_N}{A*_I}\right]^{\rho} TOT \dots \dots (11)$$

TOT are terms of trade expressed as prices of domestic exports to import prices, and ρ represents the share of the non-tradable sector in the CPI. From this model one can see that a development in the terms of trade brings about a one-on-one appreciation of real exchange rates (Coudert, 2008). Real exchange rates can also be articulated as a function of productivity and terms of trade as follows,

$$RER = \theta tot + \rho(a_x - a_n + a_n^* - a*_i) \dots \dots (12)$$

Small letters shows that the variables are expressed in logarithm and θ is parameter constrained between 0 and 1; it measures the elasticity of real exchange rates to terms of trade.

A currency whose value appreciates as the energy price or rather the energy terms of trade improves is referred to as an energy currency. Indeed, the above model suggests that improvement in the terms of trade resulting from an upsurge in export prices leads to the appreciation of the home currency. However, such appreciation could be problematic for the exporting country because it tends to bring about a decline in the manufacturing sector; this is usually referred to as 'Dutch disease' or a resource curse. Davis (1995) argues that, while people tend to use the terms Dutch disease and the resource curse interchangeably, they do not necessarily mean the same. Dutch disease is a gloomy term that simply describes the synchronicity of prosperous and lagging sectors in the economy due to a transitory or sustained surge in export earnings, whilst a resource curse refers to slow economic development for resource abundant countries. Simply put, Dutch disease refers to a situation in which, through the terms of trade, rising energy prices cause real currency appreciation and therefore reduced competitiveness, reduced exports and economic growth, de-industrialization and the re-allocation of resources. That is, resources booms occur at the expense of other sectors, particularly manufacturing (Adenauer and Vagassky, 1998).

A decline in the profitability of the manufacturing sector due to the appreciation of the currency will lead to the slower long-run growth of the economy, which is indeed the case for most Sub-Saharan African countries. However it is not this study's intention to build on existing evidence on the resource curse, nor does it focus on booming and lagging sectors. Rather, the study examines the impact of energy terms of trade on the real exchange rate.

On the other hand, an increase in energy prices or rather improved energy terms of trade, which will cause an appreciation of the domestic exchange rate, might be preferred because of its 'wealth effect' (Krugman, 1980). Because the domestic currency is expensive relative to other currencies, wealth will be transferred from the importing countries to the exporting country, resulting in current account surpluses (Coudert *et al,* 2008). Finally, the spending effect is another important effect that results from an increase in energy prices; the revenue received from exporting the commodity will be used to boost domestic aggregate demand, meet demand for imported goods, or to finance trade activities.

The above two sector models show that an improvement in relative productivity should lead to appreciation of the real exchange rate; this is commonly referred to as the Balassa-Samuelson effect.

Assuming that labour is flawlessly movable amongst the two sectors of the economy, i.e., the tradable and non-tradable sectors, tradables are subject to international competition and non-tradables are not. Because the tradables sector competes with other countries, improved productivity is more likely to occur, as countries try to beat their competitors. Thus prices will increase, leading to an upsurge in wages in the tradable sector. Workers in the non-tradable sector where productivity advances are slower will move from non-tradables to the tradable sector, forcing wages up in the non-tradable sector, which in turn appreciates the domestic real exchange rate.

It is imperative that one isolates the energy terms of trade from the terms of trade movement based on other commodities. Whilst the energy terms of trade are constructed more or less similarly to the commodity terms of trade, the difference is that when one speaks of energy terms of trade, one is referring to the ratio of exported energy prices relative to the prices of imported energy.

Amano and van Norden (1995) argued that it is important to treat energy terms of trade differently from commodity terms of trade. Persistent variations in energy prices have a different and statistically noteworthy impact on the real exchange rate. If one fails to separate energy terms of trade from other commodity terms of trade, one is likely to underestimate the effect of energy terms of trade on the exchange rate, i.e., one is more likely to obtain biased results.

Finally, most African countries and some Middle-Eastern countries depend heavily on energy exports for revenue and it is thus very important for them to understand how changes in energy prices affect their competiveness (one must remember that exchange rates are essential in measuring a country's competitiveness) (Dauvin, 2014). It is clear that when exports are energy dominated, energy prices should be the key factor in the determination of the exchange rate.

Table: 1 Foreign exchange revenue and volume of energy export growth

Nig. OilX	Nig. X rev	SA Coal X	SA Xrev	Congo OilX	Congo Xrev	Ang OilX	Ang Xrev	Moz X	Moz Xrev
9.49	20.5	1.07	28	-9	-2.61	1.01	6.95	16.83	8.43
3.87	2.89	7.31	18.51	-10	-16.17	-3.22	-5.11	13.12	20.45
-3.1	-2.29	-3.77	-7.81	-4.88	-0.79	0.74	-10.6	-8.33	7.7
-8.88	-0.43	3.87	4.05	4.89	2.67	-22.38	-8.03	-7.62	10.93
10.65	-1.39	0.07	2.39	7.42	-1.22	0.44	-6.34	9.92	10.51
2.406	**3.856**	**1.71**	**9.028**	**-2.314**	**-3.624**	**-4.682**	**-4.626**	**4.784**	**11.604**

Source: Author's own estimates based on information from the International Energy Agency and IMF WEO database, 2014.[2]

Table 1 shows the volume of export and export revenue growth for individual Sub-Saharan African countries. Growth rates for foreign exchange revenue and energy exports have been calculated using equation 10 and 11 respectively;

$$XREV\ or\ CoalX = \frac{(SA\ or\ XREV_t - SA\ or\ XREV_{t-1})}{SA\ or\ XREV_{t-1}} \ldots\ldots (13)$$

$$OilX\ or\ CoalX = \frac{(Coal\ or\ OilX_t - Coal\ or\ OilX_{t-1})}{Coal\ or\ XOil_{t-1}} \ldots\ldots (14)$$

The bottom line depicts average energy export growth and export revenue for each country. The figures below that show coal or oil export and export revenue growth plots add to the information in table 1, by plotting export growth and export revenue growth in order to determine if revenue depends on the country's level of energy exports.

[2] Notes: Nig. OilX, Nigeria oil exports growth, Nig Xrev, Nigeria export revenue growth, SA CoalX, South Africa coal export growth, SA Xrev, South Africa export revenue growth, Congo OilX, Republic of Congo oil export growth, Congo Xrev, Congo export revenue, Ang OilX, Angola oil export growth, Ang Xrev, Angola export revenues, Moz GasX, Mozambique gas export growth and Moz Xrev, Mozambique export revenues.

As can be seen from the table and figures 3(a)-3(d), a direct relationship exists between export growth and export revenue even though for some countries the relationship is not clear cut.

Figure 3(a)

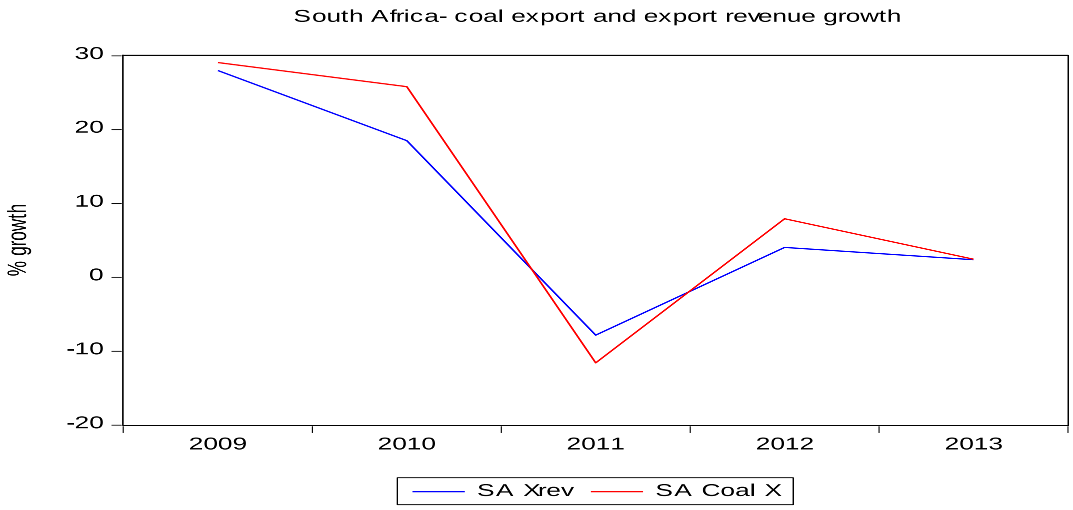


Figure: 3(b)

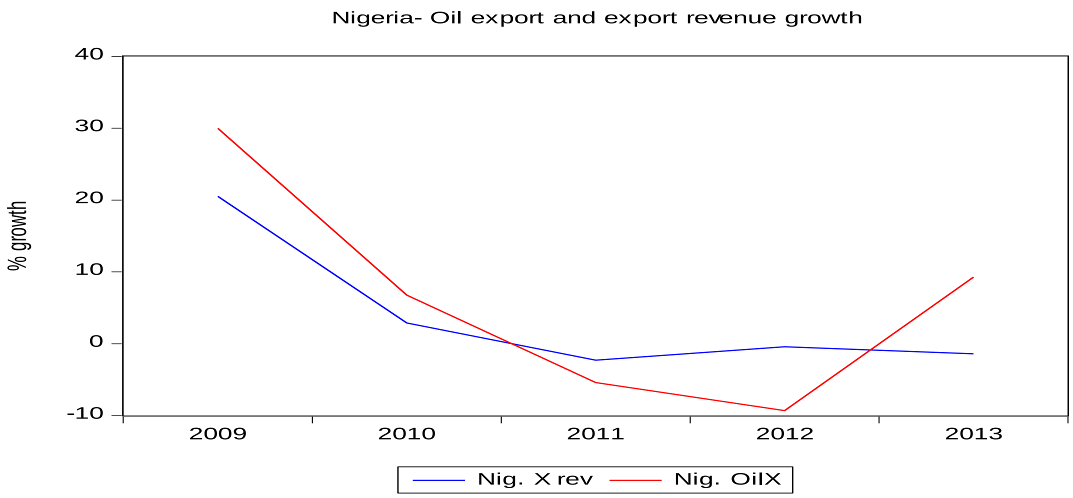


Figure: 3(c)

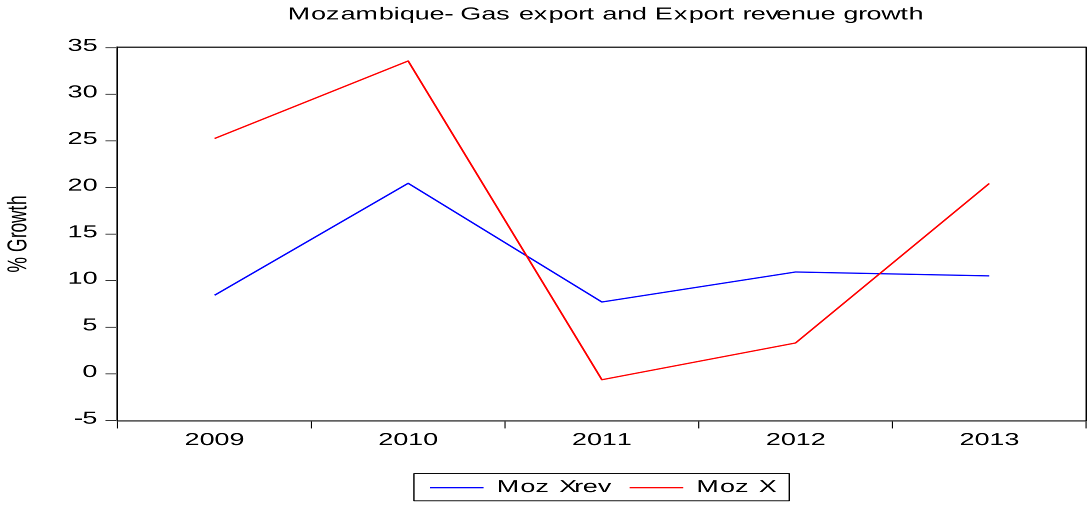
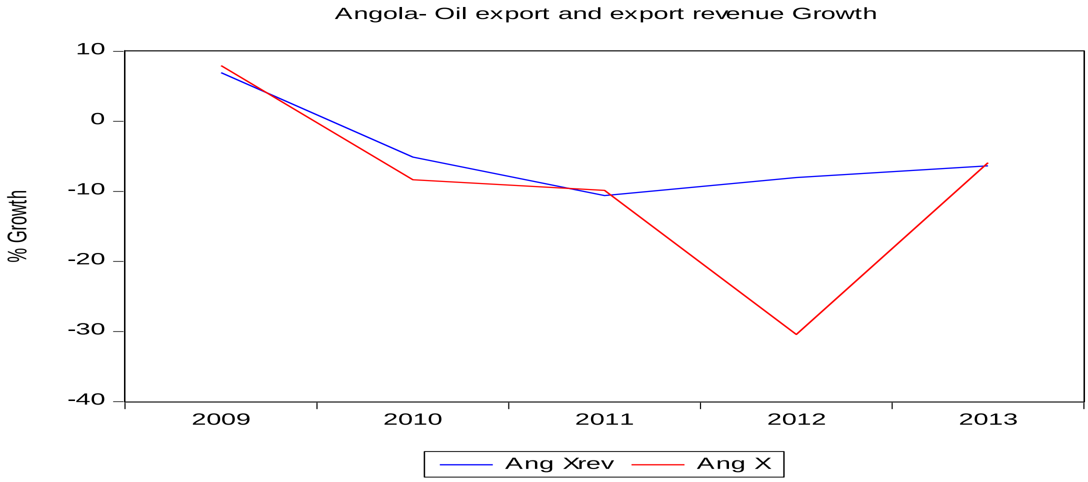


Figure: 3(d)



Source: Author's own estimates based on information from the International Energy Agency and International Financial Statistics (2014).

The direct relationship between volumes of energy exports or rather the share of a particular energy input (i.e., oil, gas and coal) and overall exports and revenue is expected to hold for one basic reason; most of the countries considered in this study tend to specialize in energy exports and hence revenue is more likely to be driven by the amount of a particular energy input which the country specialises in. Indeed, as the bottom line of table 1 shows, on average, low export growth is associated with lower levels of export revenue. Nigeria's volume of oil exports has been growing at a positive rate of approximately 2.04%, while export revenue has been growing by 3.85%. The relationship between energy export growth and export revenue in other countries is also a direct one. South Africa's volume of coal exports have been growing at 1.71%, while export revenue has been growing at a positive rate of about 9.028%; whereas Congo Republic's volume of oil exports grew at a negative rate of -2.314% and this is matched by a negative export revenue growth of about -3.624%. Angola's volume of oil exports also grew at a negative rate of approximately -4.682%, again matched by negative growth in export revenue growth of about -4.626%. Finally, Mozambique has had positive volume of gas export growth of approximately 4.784%; this corresponds with her positive export revenue growth of 11.604%. It is clear that almost all of the energy exporting countries considered in this study largely depend on energy exports for their export revenue.

2.3. Review of the empirical literature

As in the market for other commodities, energy prices are determined by supply and demand. Energy prices have soared since 1999. The historical increase in prices and the important role of the energy sector in economies have attracted interest from both researchers and policy makers. Krugman (1980) asserted that oil prices play a substantial role in the state of the economy. Hamilton's (2004) study of the impact of oil prices on macroeconomic activities concurred. Attempts have been made to use various econometric techniques to estimate the impact of energy and other commodities' terms of trade on real exchange rates (see Chen and Rogoff, 2003; and Reboredo and Rivera-Castro, 2013). Chen and Rogoff (2003) examined the association between commodity terms of trade and the exchange rate for three OECD economies, namely, Australia, Canada and New Zealand. They found that commodity prices have a significant effect on the real exchange rate. Chen and Rogoff (2003) established that real energy terms of trade led to a depreciation of the currency against the USD by 0.50%, 0.24% and 0.14% for Australia, Canada and New Zealand, respectively. Indeed, all of these studies found that energy terms of trade significantly impact the determination of the long-run exchange rate; however the findings are very mixed. Rivera-Castro found a negative relationship between the USD and oil prices.

Amano and van Norden (1995) examined the empirical relationship between real exchange rates and the terms of trade. Due to the failure of previous studies to find an empirical link between exchange rates and overall terms of trade (Lafrance and Longworth, 1987 among others), they estimated energy terms of trade and other non-energy commodities' terms of trade in isolation. They did so because they believed that the energy terms of trade play a role that is qualitatively different from that of other commodities. They found no confirmation for the PPP hypothesis, by failing to reject the unit root hypothesis. Using a single equation for cointegration, they found that both commodity terms of trade and energy terms of trade have long-run relationships with real exchange rates whilst the interest rate differential only had a transitory effect on real exchange rates. Contrary to the predictions of economic theory, they found that improved terms of trade led to a 0.223% depreciation of the Canadian dollar against the USD, and only 37.1% of disequilibrium is corrected within one year. Amano and van Norden believed that the primary reason for the negative relationship between the Canadian dollar and the energy terms of trade was the policies that were in place at the time to prevent prices from rising and that part of this contradiction could be attributed to the costs borne by other sectors when energy input prices i.e., oil, to be specific, increase.

Amano and van Norden (1998) investigated the relationship between oil prices, economic upswing and the collapse of US real effective exchange rates. They found confirmation of a unit root in both real effective exchange rates and oil prices; however they failed to reject the null hypothesis of stationarity in the interest rate's variance. They therefore concluded that the real interest rate does not describe long-run real effective exchange rate variations. Using Johansen and Juselius' approach that performs better than a single equation and the alternate multivariate approach to detect cointegration, they found confirmation of cointegration between real oil prices and US real effective exchange rates. A 1% rise in the price of oil leads to a 0.513% appreciation of the USD in the long-run; furthermore they showed that 28.6% of disequilibrium is corrected within a year. Both these studies indicate that it takes roughly three years for the exchange rate to regain its equilibrium; it is worth noting that they cover different countries.

According to Amano and van Norden, the causality runs from oil prices to real exchange rates and not the other way around. This finding was confirmed by the test for weak exogeneity. They found that oil prices were weakly exogenous and real exchange rates were not, i.e., exchange rates adjust to oil values in the long-run but prices do not. The results were not counter intuitive when one considers that the energy market is denominated in US dollars; thus even though the US is a net exporter of oil and other energies, an upsurge in oil prices implies an increase in the demand for dollars and thus appreciation of the dollar.

To enhance Amano and van Norden's (1995) findings, Chen and Chen (2007) applied monthly data panel for G7 countries from 1972:1 to 2005:1, to assess the long-run link between real exchange rates and real oil prices. Using panel techniques they identified the existence of a unit root at levels but the data was found to be stationary at first differences. Using pooled data rather than testing for cointegration in the case of individual countries, they found that the series were cointegrated and the panel techniques, fully-modified ordinary least squares, dynamic ordinary least squares and panel mean group suggested that a rise in real oil prices depreciates real exchange rates in the long-run.

Issa *et al's* (2008) study examined the evolution of the exchange rate-energy price nexus in Canada. In contrast with Amano and van Norden's (1995) and Chen and Chen's (2007) findings, they noted that the relationship between the exchange rate and energy prices, especially oil prices, shifted from negative to positive in the early 1990s. This occurred after Canada switched from being net importer of energy to being a net exporter. They argued that the reason why Amano and van Norden (1995) obtained negative results was that they used limited data, which could not fully capture the impact of the structural break that took place in 1992-3, and that the results were due to domestic energy policies and the costs borne by other firms when energy prices rose. Their main conclusion was that a rise in energy prices leads to appreciation of the Canadian dollar against the USD.

Bodart *et al* (2012) used panel data and panel cointegration techniques to assess the relationship between commodity prices and the real exchange rate for developing and emerging countries. They only used the price of primary energy input and other commodities as a regressor and assumed that other traditional variables such as the interest rates differential, the Balassa-Samuelson effect (sector-wide productivity), etc., do not significantly affect real exchange rates since most developing countries are poorly integrated into global financial markets. Using first generation methods for panel unit root which adopt a cross-sectional individuality and the second generation panel unit root method that allows for cross-sectional dependence, they found confirmation of a unit root in both real exchange rates and commodity prices. They also found that variables are integrated of order one, meaning that they have to be differenced once in order for them to become stationary. Using FM-OLS and DOLS techniques, they found, that an oil exporting country's currency, should appreciate by 3% following a 10% rise in the price of oil.

Korhonen and Juurikkala (2009) studied the association between the equilibrium exchange rates and the price of oil for nine OPEC members. They utilised panel mean group (PMG) and mean group (MG, for robustness check) and found that all of the variables included in their sample were not stationary at levels and that the data were cointegrated. While they found little evidence supporting the Balassa-Samuelson effect, they did establish that oil prices significantly affect long-run equilibrium exchange rates in both specifications.

For robustness check, they used both bilateral exchange rates and real effective exchange rates (REER). However, the data on REER was not complete and some countries' REER were not reported. Nevertheless, they found that a 10% rise in the price of oil leads to a 40-50% appreciation of real long-run equilibrium exchange rates.

Benassy-Quere *et al* (2007) examined the impact of oil prices on the dollar, given that the oil market is US dollar denominated. They found that there is a long-run link between the dollar and the price of oil. A 10% rise in the price of oil leads to a 4.3% appreciation of the dollar. Furthermore, they tested for exogeneity, and found that the prices of oil were weakly exogenous while exchanges rates were not. The causality tests underlined this relationship by indicating that causality runs from oil prices to exchange rates, but not the other way round. These findings are not surprising as one would expect that a rise in the price of oil would lead to increased demand for dollars, thus appreciating the dollar. In contrast, one would have expected that appreciation of the dollar would lead to a rise in the price of oil; however, that possibility has been proven not to hold true.

Huang and Guo (2007) examined the correlation amongst real oil price shocks, real exchange rates and other macro-economic variables in China, using the structural vector autoregressive (SVAR) technique. They failed to reject the null hypothesis of a unit root; rather they confirmed stationarity in the data after differencing. In order to specify the VAR they tested for cointegration and failed to reject the null hypothesis of a zero cointegrating vector; inferring that there was no mutual stochastic trend amongst the variables. Following a real oil price shock, real exchange rates were found to immediately depreciate in the case of China. This is not surprising as China is a net importer of oil; thus a rise in the oil price implies the transfer of wealth from oil importer to oil exporter (Krugman, 1980). However, these findings were not statistically significant and show that real exchange rates converge slowly towards their new long-run steady-state. As the forecast extends beyond three months, China experiences a 0.3% enduring appreciation in her real exchange rate. This could be attributed to the fact that China's refinery costs are lower than other countries and therefore purchase prices lag far behind those of its major trading partners due to heavy government regulation. Real oil price shocks therefore do not significantly influence China's real exchange rate.

Narayan *et al* (2008) assessed the correlation between oil prices and exchange rates in Fiji Island, using generalised autoregressive conditional heteroscedasticity (GARCH) and exponential GARCH methods. Using the unit root diagnostic test, they rejected the null hypothesis of a unit root regardless of whether or not they included a time trend. Furthermore, they employed ordinary least squares (OLS) to detect the possibility of spurious regression by testing for ARCH effect and confirmed the presence of the ARCH effect; thus the use of GARCH and EGARCH was justified. The estimation from GARCH suggested that a 10% rise in the price of oil results in a 0.2% appreciation of the Fiji dollar vis-à-vis the US dollar. The EGARCH model supported the finding that an increase in the price of oil leads to appreciation of the real exchange rate. Narayan *et al* argued that this is consistent with the economic theory, that an increase in the oil price puts pressure on inflation for the importing country; therefore it should lead to an increase in nominal interest rates, assuming that real interest rates are held constant. Hence, increased nominal interest rates will attract capital inflows to the domestic economy, appreciating the exchange rate in the long-run. This is indeed the case for Fiji and other economies.

Reboredo and Rivera-Castro (2013) employed the wavelet decomposition approach to study the link between the USD exchange rate and oil prices. They used wavelet decomposition because it is a multi-resolution technique. Orthodox econometric techniques only examine one or two time-horizons (short and long-run), while wavelet decomposition has an additional feature and can be utilised to detect contagion and interdependence between markets. Reboredo and Rivera-Castro (2013) found that before the 2008 financial crisis, the oil market and USD exchange rates were independent of each other, with correlations closer to zero for the lower-time scale and correlations were not significant for the upper-time scale. However post- and during the financial crisis there was adverse dependence among the oil market and exchange rates. In short, they noted financial contagion, i.e., financial market disturbances were transmitted to oil markets and interdependence between the oil market and exchange rates. These results resemble those of Amano and van Norden (1995, 1998), and of Chen and Chen (2003).

Zalduendo (2006) examined the determinants of Venezuela's equilibrium exchange rate. This study added other variables that are believed to be amongst the determinants of equilibrium exchange rates such as interest rates differentials, government expenditure and sectoral productivity, i.e., the Balassa-Samuelson effect. Zalduendo found that the series were nonstationary at levels but were stationary in first differences, and cointegration was found between real effective exchange rates and the specified determinants of real exchange rates. On the first regression, he found that real interest rates differentials are linked to the appreciation of REER. While oil prices were associated with the appreciation of REER; government expenditure had an inverse relationship with REER but was statistically insignificant. In his second regression he removed government expenditure and found that a 1% increase in oil prices led to $1\frac{1}{4}$% appreciation in REER; a 1% increase in the real interest rate differential led to more than 10% appreciation of REER and a worsening productivity differential led to $1\frac{1}{2}$% depreciation of REER. Using the VEC he found that it takes about 13.8 years to correct any deviation in equilibrium exchange rates.

Lizardo and Mollick (2010) applied the monetary method to equilibrium exchange rates in order to observe the effect of oil prices on the value of the USD. The model assumes that the PPP hypothesis holds; however, they found no evidence to support this hypothesis. Variables were found to be stationary after differencing and there was strong support for the presence of a long-run relationship between exchange rates, comparative money supply and comparative income. They found that an upsurge in the price of oil leads to depreciation of the USD against net oil exporters such as Mexico, Canada, and Russia's currencies. However, the USD appreciates against oil net importers' currencies. This is consistent with the predictions of the basic economic theory. An increase in oil prices implies that US as an oil importer supplies more USD, thus the value decreases.

Coudert *et al* (2008) examined the relationship between terms of trade and real exchange rates. They found confirmation of unit root and the null hypothesis of no cointegration was rejected, inferring that there is a long-run relationship between real exchange rates and the fundamentals, such as net foreign asset position, terms of trade, etc. They found that terms of trade are weakly exogenous, i.e., real exchange rates adjust to restore equilibrium and an upsurge in oil prices leads to appreciation of the real exchange rate in the range of 0.12% to 0.13%.

Dauvin (2014) pointed out that the real exchange rate for coal exporting countries (including South Africa) co-moves with terms of trade, while it is less clear-cut for natural gas and oil exporting countries, the reason being that most of these countries' exchange rates are managed, or are dollar pegged. The dollar experienced major decline in 2002 and this could be the reason why the correlation among the real exchange rates is not clear for these countries. The results suggest that a 10% improvement in terms of trade for a coal producing country such as South Africa leads to a 2.8% appreciation of the real exchange rate.

Akram (2004) argued that the puzzling results of previous studies could be due to the use of (log) linear models to estimate the link between oil prices and exchange rates. These studies assumed a symmetric effect of an increased and decreased oil price on exchange rates. Wu *et al* (2012) also argued that assuming linear correlation may fail to capture the possibly unbalanced dependence between oil and exchange rates. Akram used data covering 1971:2 - 2000:4 to estimate the relationship between oil prices and exchange rates by allowing for the asymmetric effect of the oil price on real exchange rates; he found that both the devaluation of 1986 and the depreciation of 1998 corresponded with prices below 14 USD, while the appreciation of 1996/1997 matches prices above 20 USD. In contrast with other studies, Akram pointed out that high oil prices during the Gulf War of 1990/1991 did not lead to any significant appreciation of the krone; during this period the krone was fixed to the ECU. Wu *et al* (2012) produced results somewhat similar to those obtained by Amano and van Norden (1995). Using a Copula-based GARCH model in order to account for asymmetries; they found adverse dependence between the USD and crude oil prices, i.e., a decrease in oil prices is allied with an appreciation of the dollar. These results are true from an economic perspective in the sense that the oil market is denominated in dollar prices. An upsurge in the price of crude oil means that low demand for crude oil lowers demand for US dollars; hence the dollar is expected to depreciate. With a decrease in the price of crude oil, the opposite holds true, i.e., demand for oil will increase and hence there will be greater demand for dollars. To address the shortage of dollars, the dollar must appreciate.

Contrary to Akram's argument, Wu *et al* (2012) found that an asymmetric effect does not add much to the ability of the model, whereas Akram (2004) found that the asymmetric effect could plague the results if it is not well accounted for in the model.

Several other studies adopted a broader approach by focusing not only on crude oil or other energy carrier prices in the terms of trade but on other variables that were deemed to be amongst the determinants of long-run real exchange rates including factors such as net foreign asset position and sector wide productivity, etc. Lane and Milesi-Ferretti argued that the NFA significantly affects the equilibrium real exchange rate, such that an improvement in the NFA leads to appreciation of a domestic currency. Government expenditure, sectoral productivity often referred to as the Balassa-Samuelson effect, interest rate differentials, etc., were included

Dauvin (2014), Lane and Milesi-Ferretti (2004, 2007), Jahan-Parvar and Mohammadi (2011), Neary (1988), Issa *et al* (2006), Zalduendo (2006), and Macdonald's (1998) studies.

Overall there is agreement among researchers and policy makers that real exchange rates do not follow a random walk. While there is on-going debate on what determines long-run equilibrium exchange rates, many researchers have found that currencies do respond to the energy terms of trade and other fundamentals (see Dauvin, 2014; Amano and van Norden, 1995; and Chen and Rogoff, 2003) but the point at which a country's exchange rate becomes an energy currency is still open for debate.

2.4. Conclusion

Overall, most of the empirical evidence indicates that there is a significant link between the energy terms of trade and the exchange rate of developed and developing countries alike. In particular, there is strong evidence that the exchange rate for energy exporting countries responds (by appreciating) to changes (increases) in energy prices. However the bulk of the research has focused on crude oil and developed nations such as Australia, the United States, and Canada, etc. and it cannot be assumed that these findings will necessarily hold true for developing countries, particularly Sub-Saharan African countries where little research has been conducted to date.

CHAPTER THREE

METHODOLOGY AND DATA SOURCES

3.1. Introduction

This chapter briefly describes the econometric techniques that will be employed to examine the statistical properties of the data, and the methods that will be applied in the data analysis. It also provides a concise description of data sources and the variables used to study the specific connections among the chosen variables.

3.2. Empirical Model

The stock flow approach to the equilibrium exchange rate proposed by Alberola *et al* (1999) has been applied in a number of studies, most recently Dauvin's (2013) examination of the relationship between energy prices and exchange rates.

This study employs a stock flow approach to equilibrium exchange rates which is a cointegration based view. This study follow existing studies, hence its cointegration based view. A number of studies (Roll 1979; Mishkin 1984; Piggott and Sweeney 1985; Lopez et al. 2005 and Cushman 2008) have failed to find support for the PPP hypothesis and yet many researchers such as Meese and Rogoff (1983), Milesi-Ferretti (2004) and Frankel (2007) have reached consensus that exchange rates do not move erratically but are determined by certain variables in the long-run such as net foreign asset position and terms of trade.   Exchange rates and fundamentals such as terms of trade and net foreign asset position tend to move together over time.

The failure to find evidence for the long-run PPP hypothesis suggests that the exchange rate indeed has a relationship with certain variables in the long-run; that is, in the long-run there are factors that prevent the exchange rate from reverting to its mean or rather, there are variables that move the exchange rate in the long-run, thus preventing it from being stationary and therefore preventing long-run PPP. Hence, this study examines the long-run relationship between selected variables based on both the literature and economic theory. The literature shows that exchange rates are determined by certain fundamentals in the long run; hence this model takes such relationship into consideration. The model is capable of incorporating the differences raised in the theoretical methodology, thus providing more robust results than each of the methods discussed above (chapter two).

The stock flow approach to equilibrium exchange rates is a modified version of Behavioral Equilibrium Exchange Rates (BEER). The stock flow approach thus predicts that variables such as net foreign asset, the Balassa-Samuelson effect (sectoral productivity), the interest rate differential, and terms of trade, etc., are the determinants of the equilibrium of real exchange rates. The model specified below is based on Dauvin (2014) and is as follows;

$rer_{it} = \beta_i + \boldsymbol{\gamma}'\mathbf{X_{it}} + \varepsilon_{it}$……………… (15) $\{\varepsilon_{i,t} \sim IID(0, \sigma^2)\}$

rer $_{it}$ = real exchange rates

β_i = intercept or drift term for country i,

Xit = is a set of country i's characteristics which include the energy terms of trade, net foreign asset position, real interest rate, and sectoral productivity referred to as the Balassa-Samuelson effect.

$\boldsymbol{\gamma}$ = is the coefficient capturing the impact of energy terms of trade, Balassa-Samuelson effect, real interest rate and the net foreign asset position.

ε = is an individual country's error term

Equation 12 specifies the real exchange rate as a function of economic fundamentals because the literature has established that exchange rates are not merely a function of price levels but are influenced by some economic fundamentals (Breuer, 1994 and Alberola, 1999).

3.3. Definition of Variables

This study uses data for five Sub-Saharan African countries, namely, Angola, Republic of Congo, Mozambique, Nigeria and South Africa for the period 1995-2012. The data and further data source details are found in appendix 1.

This section provides a brief explanation of the sign expectations on the variables based on economic theory discussed in chapter two. All variables other than real interest rates (RIR) and net foreign asset position (NFA) are expressed in log form. RIR and NFA should not be logged because they are already expressed in percentage terms. Variables are logged to avoid the possibility of outliers.

LNRER: The nominal bilateral exchange rate has been used and converted to the real exchange rate using GDP deflators for both the foreign country which is the US and the domestic countries which are Angola, Mozambique, Congo Republic, Nigeria and South Africa. One would have preferred the effective exchange rate over the bilateral rate; however, due to unavailability of sufficient data on the effective exchange rate, the bilateral rate has been used. The bilateral exchange rate basically means the exchange rate of two countries; in this case, these refer to the US and the Sub-Saharan African country concerned. Nevertheless, given the fact that US is the major trading partner of African countries it is expected that the USD would have substantial bearing on African currencies; hence, the estimates or rather the result would not be biased. The real exchange rate has been calculated using the equation below;

$$real\ exchange\ rate = \frac{E.GDP\ deflator_i}{GDP\ deflator_{US}}$$

Where e represents the nominal exchange rate and i represents the country in question, i.e., South Africa, Mozambique, Nigeria, Congo Republic and Angola.

NFA: the net foreign asset position of a country has been found to be among the essential determinants of the real exchange rate by various researchers such as Lane and Milesi-Ferretti (2004). In this study, the current account deficit/surplus as a percentage of GDP has been used as a proxy for NFA. An increase in the current account deficit requires that the country in question borrow in order to finance this deficit, damaging its foreign asset position. Thus the current account balance is approximately equal to NFA (Alberola, 1999).

An increase in foreign asset position is expected to have a positive influence on the domestic currency and hence appreciates the domestic real exchange rate against the USD. The data for current account as percentage of GDP has been accessed from the World Economic Outlook 2014 database. The GDP deflator has been collected from the IMF: world economic outlook database and the exchange rate have been collected from the world development indicators.

RIR: it is argued that the real interest rate is an important factor in the determination of real exchange rates in the short-run (MacDonald, 2005). If the domestic interest rate is above world interest rates, large capital inflows will be experienced by the domestic country, thus appreciating the domestic currency against the USD. Therefore, a negative sign will be expected on the real interest rate coefficient. The data on the real interest rate has been collected from the world development indicators.

LNETOT: The natural log of the energy terms of trade has been generated by simply dividing the energy export prices for the country in question by the manufacturing unit value (MUV). Therefore an improvement (i.e., an increase in the value of exports) in the terms of trade is expected to appreciate the real exchange rate. The terms of trade have been constructed in a way similar to the method used by Dauvin (2013). The data on energy prices has been collected from the IMF databases world economic outlook, while that for the manufacturing value index comes from international financial statistics.

$$ETOT_{it} = \begin{cases} \dfrac{coal\ prices}{MUV} & South\ Africa \\ \dfrac{Crude\ oil\ prices\ or\ Gas\ prices}{MUV} & Mozambique, Angola, Congo\ Republic \\ & Nigeria \end{cases}$$

LNBALASSA: Represents sectoral productivity and is usually referred to as the Balassa-Samuelson effect in the literature. It is proxied by GDP per capita and is based on the PPP GDP of the domestic country relative to its major trading partner. An improvement in sectoral productivity is expected to appreciate the real exchange rate of the domestic country's currency relative to the USD. The data on GDP per capita has been collected from the world economic outlook (IMF) database. Further details are provided in the appendix.

$$B - S\ effect = \frac{GDP\ PPP_i}{GDP\ PPP_{US}}$$

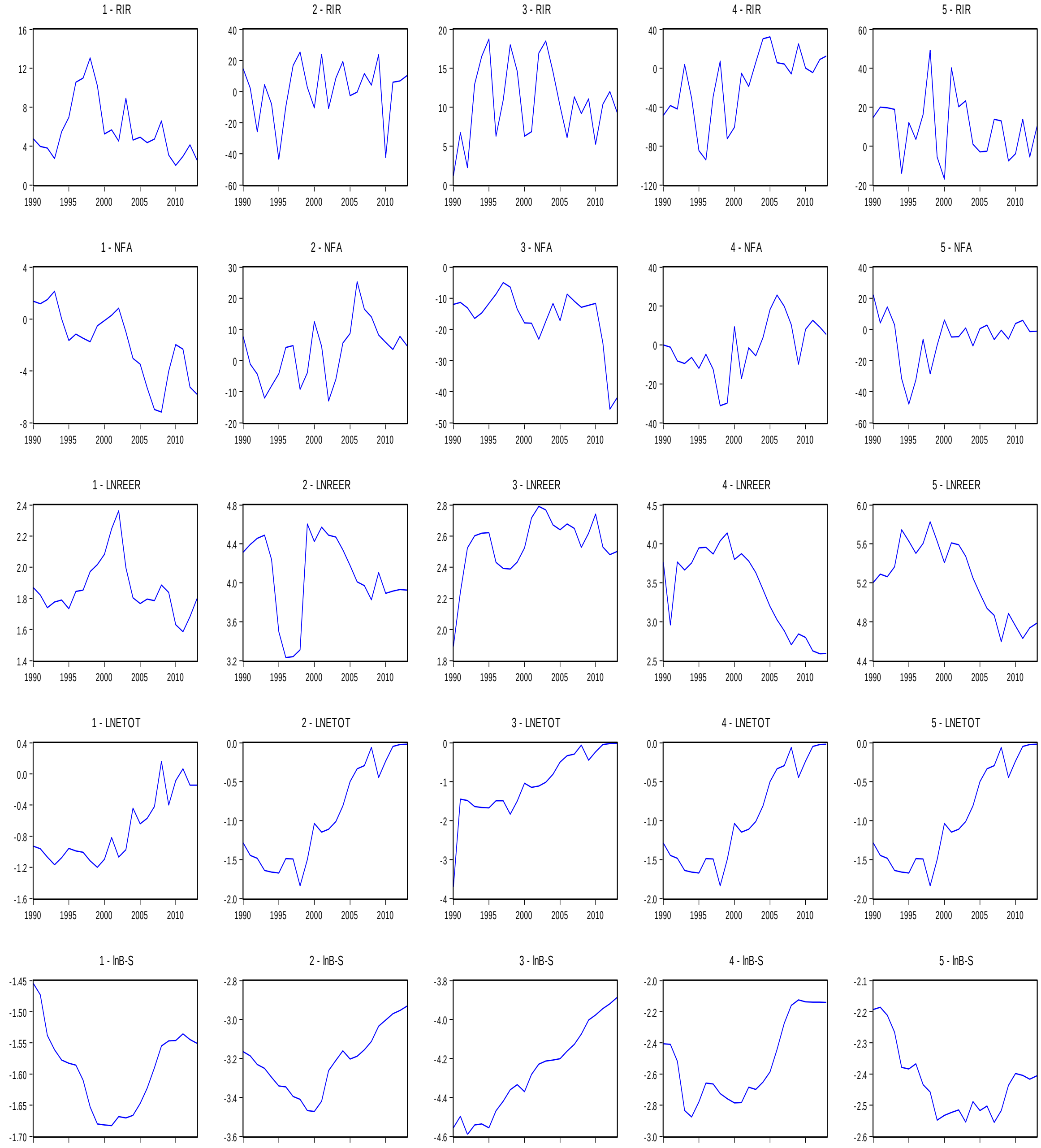
3.4. Stationary Properties of Real Exchange Rate, Sectoral Productivity, Net Foreign Asset Position and Real Interest Rate

Figure 4 shows the evolution of variables for each member of the panel (real exchange rate, terms of trade, sectoral productivity, real interest rate and net foreign asset position) over time. They all appear to have a linear positive relationship over time except for real interest rates which shows erratic evolution.

This suggests that the variables might have some form of long-run relationship or rather they revert to the same mean in the long-run. However, based on the graphical analysis one cannot conclude with certainty on the behavior of the series; thus, formal tests are necessary in order to draw conclusions about the nature of the behavior of the variables over time.

Figure 5 also displays the evolution of variables after differencing. After differencing, the variables appear to be stationary. It is worth noting that in both figures 4 and 5, the real exchange rate appears to follow the behavior of the energy terms of trade. When the energy terms of trade shrink, the exchange rate appears to be depreciating, showing a classic Dutch disease (Frankel, 2007). Figure 5 further shows that there is correlation between the exchange rate and the Balassa-Samuelson effect, confirming what has been already established in the literature review that productivity growth induces an increase in prices of non-traded goods relative to traded goods.

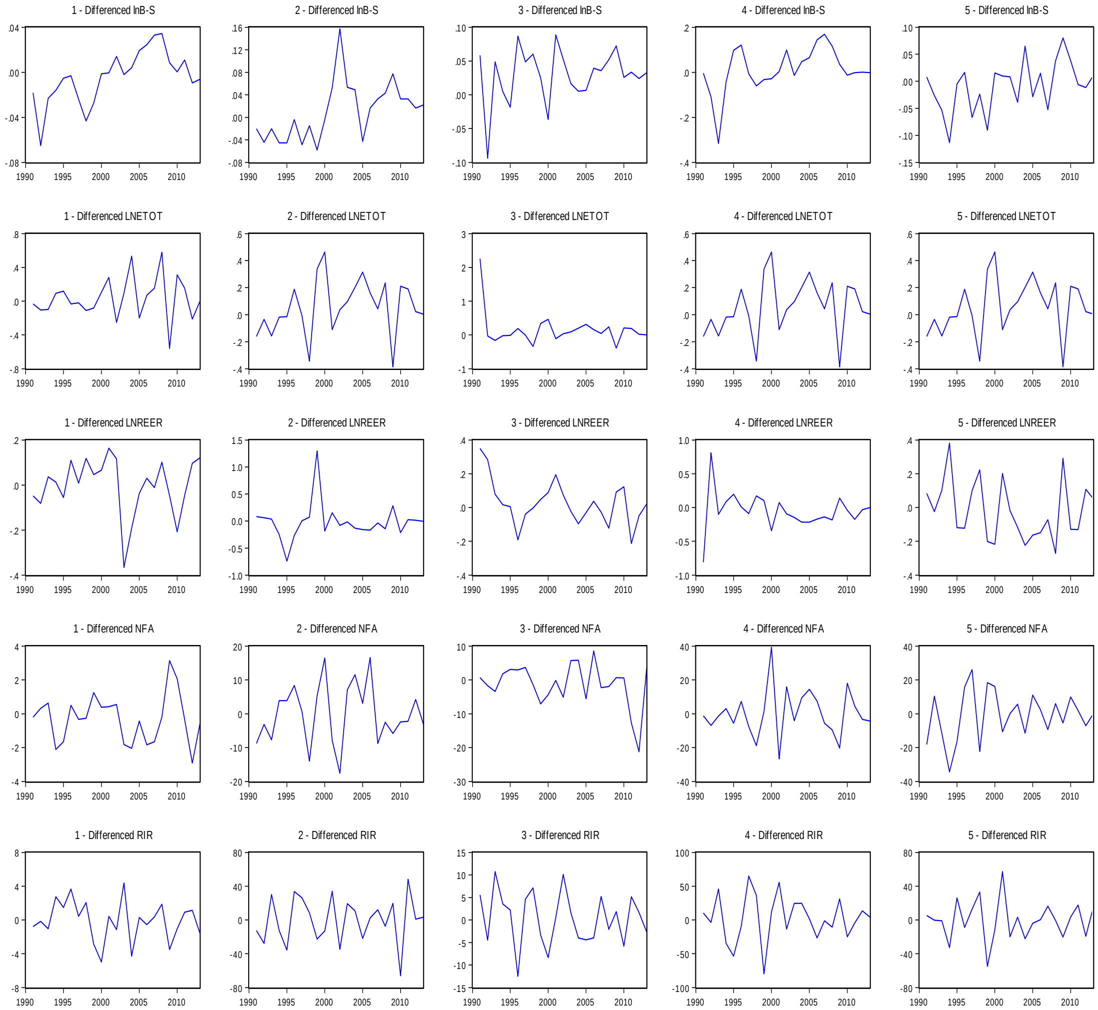
Figure: 4 Variable(s) Evolution at level



Notes: 1 South Africa, 2. Nigeria, 3 Mozambique, 4 Angola, 5 Congo Republic.

Source: Author's own estimates

Figure: 5 Evolution of Variable(s) at first differences



Source: Author's own estimates

3.5. Unit root test

3.5.1. LLC, IPS and Fisher ADF tests

It has been argued that economic variables such as the real exchange rate (Macdonald, 1996), the terms of trade and sectoral productivity follow a non-stationary process; hence testing for unit roots has become a pre-requisite for accurate and consistent estimates. Analysis for a unit root in real exchange rates carries an important implication regarding the interpretation of purchasing power parity (PPP) and the speculative simulations of real exchange rates-balance of payment nexus (Macdonald, 1996).

If one finds proof of a unit root, it indicates the rejection of PPP. Purchasing power parity basically implies that exchange rates will modify to compensate for inflation differences across countries, so that PPP is maintained. Issa *et al* (2008), Bodart (2012), Amano (1995) and Dauvin (2013) found evidence of a unit root for real exchange rates, supporting the rejection of the PPP hypothesis. While many studies support the existence of a unit root for the real exchange, Oh (1996) used panel data for 150 countries which includes G-6 and OECD countries as well as developing countries to show that the reason why other studies have failed to find evidence for PPP is limited data usage. Oh (1996) found evidence in support of PPP using panel unit root tests on the data collected from Penn world tables.

There are number of reasons for the rejection of the PPP hypothesis. The role of expectations in the fixed and flexible price market is one of the reasons; however expectations only enter the picture in the short-run period. Usually, goods market prices tend to be fixed and asset market prices are more flexible. Therefore, expectations of the asset market will cause a change in the equilibrium, leaving the goods market unchanged. This changes real exchange rates but in the long-run both markets will be in equilibrium; thus, exchange rates will be in equilibrium and PPP will hold (Oh, 1996).

It can be argued that the reason why most of the above authors rejected the PPP hypothesis is the same reason raised by Oh (1996) that the data covered a very short period of time and hence could not capture the long-run behavior in which PPP is maintained.

On the other hand, the PPP hypothesis is problematic in its formulation because, for PPP to hold, structural changes must be absent from the world economy. The presence of structural changes will change the relative price of goods and force the real exchange rate to change. Structural changes include productivity growth rate differences, etc. A notable structural change occurred in the oil market during the 1970s with the formation of the OPEC cartel that led to highly volatile commodity prices and expectations. Finally, PPP does not take capital flows into account and thus does not consider interest rates as a determinant of exchange rates.

Failure to include interest rates in the determination of exchange rates leads to misinterpretation and PPP's failure to hold. Capital flow influences exchange rates significantly through interest rates. Mundell-Fleming (1977) stated that if local interest rates are higher than world interest rates, the domestic economy will experience huge capital inflows, and greater demand for local currency. In terms of the *law of demand* one would anticipate the appreciation of the exchange rate in order to reduce demand for domestic capital; thus, the failure to include interest rates in modeling exchange rates means that this fascinating indirect link between the exchange rate and the interest rate is not captured. Due to neglect of the interest rate in the PPP hypothesis, it is less likely to hold in practice.

Levin *et al* (2002) argued that using tests that examine for indivdual unit root could erroneously result in the acceptance of the alternative hypothesis of stationarity; especially with highly insistent divergences from steady-state thus they propose a test for panel data. This has also been found to be true by a number of researchers such as Macdonald (1995), especially for small-sample sizes. Levin *et al* suggested that rather than performing an individual unit root test, one could get a powerful test by simply using panel data and thus pooling sample size. Panel data is now available to allow for such an exercise, unlike decades ago when information on other countries was very limited.

The null hypothesis is that each individual series comprises a unit against the null that each series is stationary (assumes common unit root) Levin *et al* (2002) and several other scholars utilised this test and most acknowledged that several qualifications are associated with this form of unit root testing (Levin, Lin and Chu test). These are discussed later. This is the reason why this study not only uses the LLC test, but other unit root tests for the robustness check such as the Im Pesaran and Shin (2003) test which was used by Dauvin (2014) and the Fisher ADF test.

Unit root testing is a vitally important exercise in this study. It enables the achievement of its objective, which is to check if exchange rates follow a random path or if they are stationary which will indicate that the PPP hypothesis specified in the preceding section holds. This type of analysis has been applied in numerous studies of the exchange rate such as Macdonald (1995), Amano and van Norden (1998), and Dauvin (2014), etc.

According to Levin *et al.* (2002) the initial null hypothesis is that;

$$\Delta y_{it} = \rho y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{i,t-1} + \alpha_{mi} d_{mt} + \varepsilon_{it} \dots \dots (16) \qquad \text{m=1, 2, 3}$$

Where Δy_{it} is the dependent variable for country i at time t, $d_{mt}$is the trajectory of deterministic parameters and α_{mi} is the matching vector of coefficients for each model (m=1, 2, 3). To be more specific $d_{1t} = \{0\}$, meaning that there is no deterministic variable in model one, $d_{2t} = \{1\}$ only the intercept is included in the model and lastly $d_{3t} = \{1, t\}$ both intercept term and the time deterministic component are included in model 3. Since the lag order is not known LLC recommended that three step-method be used in order to perform the test.

$\Delta y_{it} = \rho_i y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{i,t-1} + \alpha_{mi} d_{mt} + \varepsilon_{it}$ ... ... (17) m=1, 2, 3

The LLC permitsp_i, i.e., the lag order to vary across members of the panel, for a given time-series dimension (T), one must select sufficient lag order p_{max} and utilise the t-statistic of $\hat{\theta}_{il}$ to determine if a smaller lag order is preferred. The t-statistic is normally distributed with zero mean and finite variance, under the null hypothesis ($\hat{\theta}_{il} = 0$), both when $\rho_i = 0$ and when$\rho_i < 0$.

Once one knows the lag order two auxiliary regressions must be run to obtain the orthogonalised residuals, by running Δy_{it} on,$\Delta y_{i,t-L}(L = 1, \dots \dots, p_i)$ and d_{mt} to obtain the residuals, $\hat{\varepsilon} it$ and $y_{i,t-1}$ on $\Delta y_{i,t-L}(L = 1, \dots \dots, p_i)$ and d_{mt} to get$\hat{v}_{i,t-1}$. Once one has found the residuals one must standardize the residuals found on the auxiliary regressions to control for heterogeneous variances across members $\hat{\tilde{e}}_{it} = \hat{\varepsilon} it / \hat{\sigma}_{ei}$ and$\tilde{v}_{i,t-1} = \hat{v}_{it} / \hat{\sigma}_{\varepsilon i}$, $\hat{\sigma}_{\varepsilon i}$ is the standard error from each Augmented Dickey-Fuller regression.

The final step is to estimate the ratio of long to short-run standard deviation of the variable in question; one needs a variance in order to get the standard deviation; thus the long-run variance can be estimated by,

$\hat{\sigma}^2{}_{yi} = \frac{1}{T-1} \sum_{t=2}^{T} \Delta y^2{}_{it+2} \sum_{L=1}^{\bar{K}} w\bar{k}L \left[\frac{1}{T-1} \sum_{t=2+L}^{T} \Delta y_{it} \Delta y_{i,t-L} \right]$ ... ... (18)

For Bartlett Kernel $w\bar{k}L = 1 - (L/(\ \bar{k} + 1))$ for each cross-section, where $\bar{k}$ indicates a truncation lag that can also be endogenous to the data. The weighted standard deviation is estimated by$\hat{s}_n = \frac{1}{N} \sum_{i=1}^{N} \hat{s}_i$, $\hat{s}_i$ being the ratio of long-run standard deviation to innovation standard deviation estimated by$\hat{s}_i = \hat{\sigma}_{yi} / \hat{\sigma}_{\varepsilon i}$.

This now allows one to estimate the panel t-statistics by running the pooled regression, $\frac{\hat{\varepsilon}_{it}}{\hat{\sigma}_{ei}} = \rho \hat{v}_{i,t-1} + \tilde{\varepsilon}_{it}$ putting the equation into a simple form yields $\hat{\tilde{e}}_{it} = \rho \hat{v}_{i,t-1} + \tilde{\varepsilon}_{it}$. This is based on cross-section and time-series dimension $N\tilde{T}$ where $\tilde{T} = T - \bar{P} - 1$, which is the mean of the observation per member of the panel and $\bar{P} = \sum_{t=1}^{N} \frac{P_i}{N}$ which is the mean lag order of each member's ADF regression. The traditional t-statistic for H$_0$: $\rho = 0$ is $t_\rho = \frac{\hat{\rho}}{\hat{\sigma}(\rho)}$ where $\hat{\rho}$ is given by,

$$\hat{\rho} = \frac{\sum_{i=1}^{N} \sum_{t=2+p_i}^{T} \tilde{v}_{i,t-1} e_{it}}{\sum_{i=1}^{N} \sum_{t=2+p_i}^{T} \tilde{v}^2{}_{i,t-1}} \dots \dots (19),$$

$$\hat{\sigma}(\hat{\rho}) = \frac{\hat{\sigma}_{\tilde{\varepsilon}}}{\left[\sum_{i=1}^{N} \sum_{t=2+p_i}^{T} \tilde{v}^2{}_{i,t-1}\right]} \dots \dots (20) \text{ And}$$

$\hat{\sigma}_{\tilde{\varepsilon}} = \frac{1}{N\tilde{T}} \sum_{i=1}^{N} \sum_{t=2+p_i}^{T} (\tilde{e}_{it} + \hat{\rho}\tilde{v}_{i,-1})^2$ This is the estimated variance of the$\hat{\varepsilon}_{it}$. Therefore the calculated$t*_\rho = \frac{t_\rho - N\tilde{T}\hat{S}N\hat{\sigma}^{-2}{}_{\tilde{\varepsilon}}\hat{\sigma}(\hat{\rho})\mu*_{m\tilde{T}}}{\sigma*_{m\tilde{T}}}$, with $\mu*$ and $\sigma*$ being the mean and standard deviation of adjustments given by LLC in table 2 (see Levin *et al,* 2002).

The LLC test performs better than traditional time-series tests for unit root, in the sense that they have enough power against the alternative hypothesis. However the issue with this test is that it assumes cross-sectional independence. Thus it fails to perform better in a situation where cross-sections are dependent on each other. Due to the openness of many economies one would expect cross-sectional dependence on exchange rates and other fundamentals such as productivity and terms of trade; therefore one cannot simple rely on the LLC test alone. The other limiting assumption of this model is that members of the panel have a common unit root process. This is not always the case as it is possible to find cases where some series are nonstationary while other countries or panel member are stationary. Hence, Im Pesaran and Shin (20003) (IPS, hereafter) developed a model to address the issue of common unit root process; thus IPS will also be used to circumvent issues that might arise with the assumption of common unit root.

Im *et al* (2003) proposed a test that they argued might be superior to other competing panel unit root tests. This test is simple and straight-forward; it is based on the average of idiosyncratic unit root statistics for panels. Basically, this is the mean of the Dickey-Fuller statistics for each member in the panel which Im *et al* (2003) refer to as t-bar.

This test allows for serial correlated residuals and heterogeneity of the dynamics as well as error variances across the members of the panel. The basic framework for the test is as follows;

$y_{it} = (1 - \emptyset_i)\mu_i + \emptyset_i y_{i,t-1} + \varepsilon_{it,} \dots \dots (21)$ i=1…N, t=1…T,

This can be expressed as follows;

$\Delta y_t = \alpha_i + \beta_i y_{i,t-1} + \varepsilon_{it} \dots \dots (22)$

Therefore the null hypothesis is H_0: $\beta = 0$ against the alternative H_1: $\beta < 0$ i= 1, 2….N $\beta_i = N + 1, N + 2 \dots \dots \dots N$ the alternative null hypothesis is formulated differently from the usual hypothesis as it allows for β_i to differ across members and is more rational than homogenous alternative hypothesis $\beta_i = \beta < 0$ for all individuals. This allows some individual series to be stationary rather than assuming that they are all non-stationary.

Although the test proposed by Im *et al* seems to perform better than the LLC test it does have its limitations. It does a very good job by allowing for heterogeneous unit root across members; however it uses common lag length in the individual ADF regression. This somewhat limits the test. Therefore, a Fisher ADF type test was proposed, which allows for different lag length in individual ADF regression. This test does not differ significantly from the IPS test except for the above mentioned advantage; thus the Fisher ADF type test will utilised for robustness check. The Fisher ADF test simply averages the p-values from unit root for each cross-section to test the null of a unit root in panel data.

Table 2 displays the results for each test with panel a, panel b and panel c displaying LLC, IPS and Fisher ADF, respectively. The results display each variable on its level form and also at its differenced form.

Table: 2 Unit root test results summary at levels

Results reported are in Level Form					
Test Type	***Lnreer***	***lnETOT***	***lnB-S***	***NFA***	***RIR***
LLC	-0.56661 (0.285)	0.25918 (0.602)	0.09512 (0.538)	-0.82664 (0.204)	-4.5908 (0.000)
IPS	-1.5335 (0.662)	1.65066 (0.951)	0.95266 (0.830)	-1.08267 (0.140)	-4.45781 (0.000)
Fisher ADF	-1.47078 (0.707)	1.73979 (0.959)	0.96929 (0.8338)	-1.10485 (0.135)	-3.96924 (0.000)
Notes: P-values are reported in parentheses. All tests include individual effect.					

Source: Author's own estimates

Table 3 Unit root test results summary at first differences

First Differences					
Test Type	***Lnreer***	***lnETOT***	***lnB-S***	***NFA***	***RIR***
LLC	-8.72618 (0.000)	-4.40648 (0.000)	-3.09754 (0.000)	-9.02432 (0.000)	-6.27828 (0.000)
IPS	-8.28656 (0.000)	-7.44353 (0.000)	-3.70324 (0.000)	-7.42896 (0.000)	-8.46469 (0.000)
Fisher ADF	-6.69048 (0.000)	-6.62336 (0.000)	-3.58947 (0.000)	-6.53835 (0.000)	-7.23964 (0.000)
Notes: *P*-values are reported in parentheses. All tests include individual effect.					

Source: Author's own estimates

According to the LLC, real exchange rates have a unit root at all orthodox levels of significance (1%, 5% and 10% levels). The other two tests, Fisher ADF and IPS show that real exchange rates indeed contain a unit root, since one fails to reject the null hypothesis that exchange rates have a unit root at all conventional levels of significance; as displayed in table 2.

Many researchers such as Amano and van Norden (1995, 1998) and Macdonald (1995) have provided evidence that real exchange rates are not stationary, leading to the rejection of the PPP hypothesis. The above findings concur with previous findings and contradict Breuer (2001) who found evidence for the PPP hypothesis.

It is not surprising that the PPP hypothesis does not hold. Sub-Saharan African countries usually have very high levels of inflation relative to other countries, particularly Western and European countries. For example South Africa's target inflation rate target is 3-6% whereas the United States' target is only 2%. Assuming that both countries reach their upper target band of 2% and 6% for the US and South Africa, respectively, this implies that there will be a 4% inflation difference between them. For the PPP hypothesis to hold inflation differences should not exist or a depreciation of a dollar must be accompanied by a 4% increase in inflation so that prices are equalized between the two countries when converted to a single currency. Failure of PPP simply indicates that exchange rates indeed have a unit root; hence, disturbances to equilibrium real exchange rate are prolonged. Exchange rates in the long-run are indeed determined by some factors such as NFA, the Balassa-Samuelson effect and terms of trade (Mendoza, 2004).

The LLC test suggests that sectoral productivity, i.e., the Balassa-Samuelson effect is nonstationary and the IPS and Fisher ADF tests suggest the same. The IPS and Fisher ADF tests are less restrictive in nature, since they allow for heterogeneous unit root, unlike LLC which assumes common unit root and cross-sectional independence. This is why they have been employed for robustness check; these tests are also robust in the presence of cross-sectional dependence. As noted earlier, there are a number of ways in which sectoral productivity could be cross-sectional dependent; thus the IPS and Fisher ADF tests are more relevant in this regard. Globalization allows countries to trade technologies which might boost productivity in other sectors; it also promotes competition among different cross-sections, which encourages the same sector in both foreign and local economies to become more productive in order to avoid being eliminated in the market.

The LLC, IPS and Fisher ADF tests reveal that energy terms of trade contain a unit root; hence, the null hypothesis of a unit root cannot be rejected. All three tests suggest that the net foreign asset position contains a unit. The null hypothesis could not be rejected at all conventional levels of significance.

Dauvin (2014) and Amano and van Norden (1995) found that real interest rates only have a transitory effect on real exchange rates; they found that real interest rates do not have a unit root or were stationary. Using IPS, LLC and Fisher ADF, this study finds that real interest rates are indeed stationary at levels; thus they only have a transitory effect on the real exchange rate.

All the variables except for real interest rates were nonstationary at levels as reported in Table 2; therefore they were differenced and tested for unit root again and found to be stationary at first differences (see Table 3). Given this finding, the model has been transformed as done by Amano and van Norden (1995); such that it is now expressed in first differences. The model is therefore specified as follows;

$$\Delta lnreer = \beta_{oi} + \beta_i \Delta lnETOT + \beta_i \Delta lnBS + \beta_i \Delta NFA + \varepsilon_{it} \ldots \ldots (23)$$

Δ Denotes the first difference operator; one notices that the real interest rate has been omitted in this model. This is justified by the unit root tests. All three unit root tests provided evidence that real interest rates are stationary at levels; hence they only have a transitory effect on the equilibrium exchange rate and are of little interest in this study which specifically focuses on the long-run rather than the short-run relationship. Since all other variables have been found to be nonstationary at levels, but stationary at differences, i.e., they are $I(1)$ process, the next step is to examine if they are integrated, i.e., they can never wander far apart in the long-run or rather in the long-run they always revert to the same mean.

Before moving on to the examination of cointegration it is important to note the qualifications of the test performed above and to examine the possibility of cross-sectional dependence which will then dictate the kind of test to be utilised to examine the cointegration.

3.5.2. Panel Unit Root Test Qualification

Panel unit root tests have better statistical power and can easily reject a false null hypothesis of a unit root. It is for this reason that a number of scholars such as MacDonald (1995), Dauvin (2014), etc. have utilized panel data. However, Breuer *et al* (2001) argued that although panel unit root tests have increased power through pooling data from various cross-sections they do have significant limitations.

Tests such as the one developed by Levin *et al* (1992) are commonly used to evaluate the possibility of a unit root in the panel data. However, they are not accurate and should thus be interpreted with the utmost care (Breuer *et al,* 2001). Breuer *et al* (2001) utilised data covering 1950 to 1995 to examine unit root in the real exchange rate of 14 OECD countries. They found that if nonstationary t series are greater than stationary series, the panel unit root test assumes that exchange rates are nonstationary across all members of the panel, regardless of those that are stationary and vice versa.

3.6. Cross-sectional dependence

Cross-sectional dependence is the correlation between the error terms. It can result from various factors, such as common shocks and unobserved components that become part of the error term.

While the presence of cross-sectional dependence presents a challenge to panel data, existing tests for panel data tend to ignore it. However, if cross-sectional dependence in the data is indeed present and is ignored as is usually the case, the reduction in efficiency may provide little benefit over the utilization of a single OLS equation.

Prior to testing for cointegration, this study tests for cross-sectional dependence using the test proposed by Pesaran. Consider the orthodox empirical model established in this section of this study.

$$lnreer_{it} = \alpha_i + \beta' x_{it} + \varepsilon_{it}, \dots \dots (24) \quad i = 1, \dots, N \ and \ t = 1, \dots, T$$

As before x_{it} is a Kx1 vector of independent variables, i.e., net foreign asset position, energy terms of trade, the Balassa-Samuelson effect and the real interest rate, β is vector of coefficients to be estimated and α_i are idiosyncratic effect, last term represent error term and are assumed to be identically, independently distributed over time, and across cross-sections.

The null hypothesis is therefore stated as

$H0\text{:} \rho_{ij} = \rho_{ji} = cor(\varepsilon_{ji}, \varepsilon_{ji}) = 0 \ for \ i \neq j,$ (no-cross sectional dependence) and against the alternative hypothesis of cross-sectional dependence which can be simply specified as follows;

$$H1: \rho_{ij} = \rho_{ji} \neq 0 \; for \; some \; i \neq j$$

Where ρ_{ij} is the product-moment correlation coefficient of the disturbances and is given by $\rho_{ij} = \rho_{ji} = \frac{\sum_{t=1}^{T} \varepsilon_{ji}\varepsilon_{ji}}{(\sum_{t=1}^{T} \varepsilon_{it}^2)^{\frac{1}{2}}\left(\sum_{t=1}^{T} \varepsilon_{jt}^2\right)^{1/2}} \dots \dots (25)$

The amount of possible combinations $(\varepsilon_{it}, \varepsilon_{jt})$ grows with N. Breusch and Pagan (1980) proposed the LM test which is only valid for fixed $N \; as \; T \longrightarrow \infty$ which is therefore given by $LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2$, $\hat{\rho}$ being the estimate of pairwise link of the residuals. This test is more likely to result in severe size distortions with large N and finite T; this is because the test is specially designed for fixed N and infinite T, so the bias is likely to become worse when N is increased. It is for this reason that Pesaran (2004) developed a CD test with the following alternative.

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=1+1}^{N} \hat{\rho}_{ij} \right) \dots \dots (26)$$

Pesaran (2004) also demonstrated that the null hypothesis of no cross-sectional dependence $CD \overset{d}{\rightarrow} N(0,1) for \; N \longrightarrow \infty \; and \; adequately \; large \; T.$ In contrast with the LM test, the CD test has mean equal to 0 for stable values of time and cross-sections.

H_0: Cross-sectional independence

H_1: Cross-sectional dependence

Pesaran's test of cross-sectional independence= 1.506, Pr= 0.1322

Average absolute value of the off-diagonal element = 0.305. The Pesaran test suggests that there is no cross-sectional dependence, since one fails to reject the null hypothesis at all conventional levels of significance. Furthermore, the absolute value of correlation is low at 0.305; hence there is satisfactory confirmation of no cross-sectional dependence.

3.7. Cointegration Testing

This study will employ the test for cointegration proposed by Kao (1999). The test is residual-based; it tests for cointegration by examining the behavior of the residuals. If the residuals contain a unit root or rather are not well-behaved the series are not cointegrated but if the residuals are stationary then one can simply infer that the series are cointegrated; thus there is a long-run equilibrium relationship amongst them.

This test is a panel test; it thus has better power to reject the (*false*) null hypothesis of non-stationarity or rather of no cointegration therefore accepting the alternative hypothesis (Oh, 1996; Kao, 1999). However, as Breuer (2001) noted, the test has some limitations. Breuer argued that while panel unit root and cointegration have undeniable advantages over other orthodox time-series tests, the panel test fails to identify or to isolate members whose series are nonstationary or not cointegrated. The panel cointegration test follows the assumption of *all or nothing*, i.e., either all the series in the panel are stationary (cointegrated) or they are all nonstationary (not cointegrated). Breuer (2001) added that if a panel contains a large number of series which are not cointegrated, the panel test will simply conclude that all variable members of the panel have non-cointegrated series.

The model to be estimated is as follows and only includes the variables that have been found to be nonstationary at levels such as NFA, terms of trade, Balassa-Samuelson and real exchange rate in order to examine if they have some form of long-run association (see table 3.3.1)

$y_{it} = \beta_i + \beta' x_{it} + \varepsilon_{it} \dots\dots (27)$, i=1…N and t=1…T

Where subscript i, represents individual member of the panel , t indicates time dimension, y is the dependent variable; in this case it is the real exchange rates, β represents individual intercept, $\beta' x$ is the vector of coefficients to be estimated based on a set of each member's characteristics and ε, is the error term, assumed to be identically and independently distributed across sections.

After the examination of the stationarity properties and having found that the variables are not stationary at levels except for real interest rates, but are stationary at first differences, at this point one wants to examine the existence of the long-run relationship commonly known as cointegration. The Kao test closely follows the Dickey-Fuller test for cointegration based on residual.

Dickey-Fuller Test for the Null hypothesis of No Cointegration

$\hat{e}_{it} = \gamma\hat{e}_{it-1} + \epsilon_{it}$ … … (28)

Where ê, is the estimate of ε_{it} from the equation…, the null hypothesis is that there is no cointegration and the alternative is that indeed the series are cointegrated. Thus the null and alternative hypothesis could be formally depicted as follows;

H0: $\gamma = 1$

H1: $\gamma = 0$

This basically requires that the residual be stationary in order for series to be cointegrated. The null hypothesis that series are nonstationary is tested by the following expression;

$$\sqrt{NT}(\hat{\gamma} - 1) = \frac{\frac{1}{\sqrt{N}}\sum_{i=1}^{N}\frac{1}{T}\sum_{t=2}^{T}\hat{e}_{it-1}\Delta\hat{e}_{it}}{\frac{1}{N}\sum_{i=1}^{N}\frac{1}{T^2}\sum_{t=1}^{T}\hat{e}^2{}_{it-1}}$$

$$= \frac{\frac{1}{\sqrt{N}}\sum_{i=1}^{N}\frac{1}{T}\sum_{t=2}^{T}\hat{e}^*_{it}\Delta\hat{e}*_{it}}{\frac{1}{N}\sum_{i=1}^{N}\frac{1}{T^2}\sum_{t=2}^{T}\left(\hat{e}^*_{it-1}\right)^2}$$

$$= \frac{\sqrt{N}\frac{1}{N}\sum_{i=1}^{N}\frac{1}{T^2}\Psi_{3it}}{\frac{1}{N}\sum_{Ni=1}^{N}\Psi_{4it}}$$

$$= \frac{\sqrt{N}\Psi_{3it}NT}{\Psi_{4it}NT} \text{ … … (29)}$$

$\hat{e}^*_{it}$ is defined in equation (28),$\Psi_{3it} = \frac{1}{T}\sum_{t=2}^{T}\hat{e}^*_{it}\,\Delta\hat{e}*_{it}$,$\Psi_{4it} = \frac{1}{T^2}\sum_{t=2}^{T}(\hat{e}^*_{it-1})^2$, $\Psi_{3it}NT = \frac{1}{N}\sum_{i=1}^{N}\frac{1}{T^2}\Psi_{3it}$ and $\Psi_{4it}NT$=$\frac{1}{N}\sum_{Ni=1}^{N}\Psi_{4it}$. The t-statistics to test the null hypothesis is as follows;

$$t_\gamma = (\hat{\gamma} - 1)\frac{\sqrt{\sum_{i=1}^{N}\sum_{t=2}^{T}\hat{e}^{*2}_{it-1}}}{se} \text{ … … (30)}$$

Presume that the asymptotic theory that is being followed is a sequential theory such that T⇒ ∞ followed by N⇒ ∞ and also that the error terms are independently and identically distributed across the member of the panel then, $\sqrt{NT}(\hat{\gamma} - 1) - \sqrt{N}\frac{\rho_{3t}}{\rho_{4t}} \Rightarrow N(0.3 + \frac{36\sigma_v^4}{5\sigma_v^4}$ and, $t_\gamma - \frac{\sqrt{4}\rho_{3T}}{se\sqrt{v_{4T}}} \Rightarrow N(0, \frac{\sigma_{0v}^2}{2\sigma_v} + \frac{3\sigma_v^2}{100_{0v}^2})$

Where $\rho_{3t} = E[\Psi_{3,T}]$ and $\rho_{4t} = E[\Psi_{4,T}]$ one can simply point out that the asymptotic distribution of the t-statistics, $\sqrt{NT}(\hat{\gamma} - 1)$ and t_γ relies on the irritant parameters ρ_{3t},ρ_{4t}, σ_v^2 and, σ_{0v}^2. Thus it becomes essential to construct new statistics whose distribution is independent of the nuisance parameters. Thus the following is now defined,

$$D_{f^*\gamma} = \frac{\sqrt{NT}(\hat{\gamma}-1)+\frac{\sqrt[3]{N\sigma_v^2}}{\sigma^2{}_{0v}}}{3+\frac{36\hat{\sigma}_v^4}{5\hat{\sigma}_{0v}^4}} \ldots\ldots (31), \text{ and}$$

$$D_{f^*t} = \frac{t_\gamma+\frac{\sqrt{6}N\hat{\sigma}_v}{2\sigma^2{}_{0v}}}{\sqrt{\frac{\hat{\sigma}_v^2}{2\hat{\sigma}_v^2}+\frac{3\hat{\sigma}_v^2}{10\hat{\sigma}_{0v}^2}}} \ldots\ldots (32)$$

This demonstrates that the constraining distribution of $D_{f^*\gamma}$ and D_{f^*t} by construction does not depend on the nuisance parameters; thus it can be shown that $D_{f^*\gamma} \Rightarrow N(0,1)$ i.e., it is normally distributed with zero mean and 1…. and $D_{f^*t} \Rightarrow N(0,1)$ by sequential theorem i.e., T$\Rightarrow \infty$ then N$\Rightarrow \infty$.

If one uses OLS in nonstationary variables the results are more likely to be spurious. A spurious regression is a result that appears to be correct, but is not. Thus if one finds evidence of a unit root i.e., the series is not stationary, the following exercise tests for cointegration.

The main purpose of this study is to determine if the energy terms of trade are indeed the main (part) of the long-run equilibrium exchange rate. This can be done by testing for cointegration and proceeding to estimate the long-run coefficients if indeed the series are cointegrated. The table below depicts the results for the cointegration test which is commonly used in this kind of analysis. The test was proposed by Kao (1999) and assumes cross-sectional independence; nevertheless, it is widely used in panel data analysis as discussed above and fits the data perfectly as it has been found that there is no cross-sectional dependence. Hence the use of the Kao Test is also justified by the cross-sectional dependence test carried out in the preceding section.

Table: 4 Cointegration test

Co	t-Statistic	Prob.
ADF	-1.969844	0.0244
Residual variance	0.046494	
HAC variance	0.024179	

Source: Author's own estimates

As shown in the above table, the null hypothesis of no cointegration has to be rejected at all conventional levels of significance better than 2.4%, i.e., 5% and 10% level of significance. Therefore, despite the fact that the Kao test for cointegration fails to account for cross-sectional dependence, one can still reject the false null hypothesis of no cointegration; hence the series do have a long-run relationship.

The cointegration basically shows that even though the series may wander apart in the short-run, in the long-run they will come back together. This relationship is usually referred to as *the drunk and his blind dog*. It is therefore concluded that the series employed in this study are indeed cointegrated except for interest rates which has been found to be stationary. For series to be cointegrated they should be of a same order. All our series have all been found to be difference stationary, except for the interest rates. The next step is to estimate the cointegrating equation in order to determine the values of the elasticities.

3.8. Long-run Coefficients Estimating Techniques

The coefficients of the long-run relationship are derived by employing the mean group of individual dynamic ordinary least squares (DOLS) and fully modified ordinary least squares. The dynamic ordinary least square for each member of the panel can be written as follows;

$$Y_{i,t} = \beta_0 + \sum_{i=1}^{n} \beta_n X_{i,t} + \sum_{i=1}^{n} \sum_{j=-kb}^{kl} Y_{i,j} \Delta X_{i,t-j} + \varepsilon_t \dots \dots (33)$$

kl and kb are leads and lags, respectively.

The fully modified ordinary least squares were original designed by Phillips and Hansen (1990) to provide optimal estimates of cointegrating regressions. The FMOLS modifies OLS in order to account for serial correlation effects and endogeneity in the regressors that result from the existence of a cointegrating relationship (Phillips, 1995). The FMOLS allows for both stationary and nonstationary series, hence one does not need to worry about the form and statistical properties of the data when estimating long-run relationship.

FMOLS is appropriate for heterogeneous cointegrated panels (Pedroni, 2000). The following cointegrated system is therefore considered,

$$Y_{it} = \beta_i + x'_{it}\delta + \varepsilon_{it} \dots\dots (34)$$

$$x_{it} = x_{i,t-1} + \omega_t \dots\dots (35)$$

Where $\xi_{it} = [u_{it}, e'_{it}]$ is stationary with covariance matrix Ω_i, a semi-parametric correction can be made to the OLS estimator to eliminate the second order of bias caused by endogeneity in the regressors (Phillips and Hansen, 1990 and Phillips, 1995). The same principle has been followed by Pedroni (2000) in panel data context, allowing for heterogeneity in the short run dynamics and fixed effects. The Pedroni's estimator is

$$\dot{\beta}_{FM} - \beta = \left(\sum_{i=1}^{N} \widehat{\Omega}_{22i}^{-2} \sum_{t=1}^{T} (x_{it} - \bar{x}_t)^\wedge 2 \right)^{-1} . \sum_{i=1}^{N} \widehat{\Omega}_{11i}^{-1} \widehat{\Omega}_{22i}^{-1} \left(\sum_{t=1}^{T} (x_{it} - \bar{x}_t)\mu_{it}^* - T\hat{\gamma}_i \right) \dots\dots (36)$$

$$\mu_{it}^* = \mu_{it} - \widehat{\Omega}_{22i}^{-1}\widehat{\Omega}_{21i}, \hat{\gamma}_i = \hat{\Gamma}_{21i} + \widehat{\Omega}_{21i}^{0} - \widehat{\Omega}_{22i}^{-1}\widehat{\Omega}_{21i}\left(\hat{\Gamma}_{22i} + \widehat{\Omega}_{22i}^{0}\right) \dots\dots (37)$$

Where the covariance matrix can be decomposed as $\Omega_i = \Omega_i^0 + \Gamma_i + \Gamma_i$ where Ω_i^0 is a contemporaneous covariance matrix, and Γ_i is a sum of autocovariances. Also, $\widehat{\Omega}_i^0$ denotes an appropriate estimator of contemporaneous covariance matrix (Christopoulos and Tsionas, 2004).

3.9. Granger Causality Testing

To achieve one of the objectives of this study a Granger causality approach will be employed. In a simple setting the first variable is said to Granger Cause the second if the forecast of the second variable improves when the lagged values of the first variable are taken into account (Hoffmann *et al,* 2005 and Granger, 1969). This study employs Hurlin and Vent's (2001) panel data Granger causality procedure. Consider the time-stationary vector autoregressive representation, adapted to a panel data context. For each member of the panel, we have $\forall t \epsilon [1, T]$

$$Y_{it} = \sum_{k=}^{p} \gamma^{(k)} Y_{it-k} + \sum_{k=}^{p} \beta_i{}^{(k)} x_{i,t-k} + \varepsilon_{it} \dots \dots (38)$$

Where $p\epsilon\aleph^*$ and $\varepsilon_{it} = \alpha_i + v_{it}$ where error terms are independently and identically distributed across members of the panel with zero mean and a constant variance. In this case, the variables employed in this study i.e., energy terms of trade, real exchange rate, productivity, and net foreign asset position, are in turn fitted into equation 34 as LHS variables. Hurlin and Vent (2001) assume that $\gamma^{(k)}$ and $\beta_i{}^{(k)}$ are constant $\forall k\epsilon[1, p]$ and $\beta_i{}^{(k)}$ is heterogeneous across members but $\gamma^{(k)}$ is identical across members of the panel. This therefore forms the framework for Granger causality testing in panel data context. The Hurlin and Vent technique is comprised of three steps; however, this study will only conduct the first step since the purpose is to examine Granger causality between the specified variables. The first step examines the identical non-causality hypothesis, given by;

H_0: $\beta_i{}^{(k)} = 0 \quad \forall i\epsilon[1, N], \forall k\epsilon[1, p]$

H_1: $\exists(i, k)/\ \beta_i{}^{(k)} \neq 0$

The null hypothesis suggests that there is no causal relationship across N. If the null hypothesis is rejected there is evidence of Granger causality.

3.10. Conclusion

The chapter provided a full description of the econometric techniques used to examine the statistical properties of the data and also provided a concise description of the empirical model used, the stock flow approach proposed by Alberola (1999, 2002). Three versions of unit root test have been employed and all series are found to be stationary after differencing except for interest rate. Furthermore, long-run coefficients were estimated using DOLS and FMOLS, both of which have been concisely explained in this chapter.

CHAPTER FOUR

EMPIRICAL FINDINGS

4.1. Introduction

This chapter presents and interprets the findings obtained by running dynamic OLS and fully-Modified OLS. This will enable one to draw inferences and provide answers to the research question. It will also suggest the direction of the policies that a country should adopt in order to cope with developments and volatility in the energy market, thus avoiding the negative consequences of such developments.

4.2.Empirical analysis

As noted in chapter three, spurious regression might be obtained if OLS is used in the presence of non-stationary data series. Hence this study employs fully-modified OLS and dynamic OLS to estimate the long-run elasticities. FMOLS and DOLS allow one to estimate the common long-run relationship in the presence of heterogeneity across individual members of the panel. Both these techniques are asymptotically unbiased, and provide standard normal distributions that are free from nuisance parameters. However, one would expect the results from DOLS to be more appealing than orthodox OLS and FMOLS estimates. OLS produces biased estimates and standard normal distribution depends on nuisance parameters. FMOLS suffers more from severe size distortions than DOLS; hence DOLS is preferable (Anderson and Hsiao, 1982). Although the fully-modified version of OLS has its shortcomings, it tackles the issue of endogeneity in the regressors and the autocorrelation of residuals. If attention is not paid to the issue of endogeneity, the estimates are more likely to show incorrect signs. Furthermore, the DOLS has the additional advantage of computing convenience.

The results for FMOLS and DOLS are displayed in tables 5 and 6, respectively. First and foremost, both models seem to be able to explain large variations in the endogenous variable i.e., the real exchange rate. FMOLS and DOLS are able to explain 94% and 96% of the variations, respectively; the standard errors are quite low for both regressions, but DOLS continues to prove itself the most efficient way of estimating with even lower standard error of the regression relative to its counterpart, i.e., fully-modified OLS. Standard errors of regression are displayed at the end of both tables 5 and 6.

Table: 5 Fully-Modified Ordinary Least Squares Estimates

Fully-Modified OLS Regression dependent variable is lnrer			
Var. Name	**Coefficient**	**Standard error**	**t-statistic**
lnETOT	-0.168***	0.062499	-2.695707
lnB-S	-0.44**	0.1972	-2.23164
NFA	-0.011***	0.002597	-4.423784
R-Squared 0.944541 Standard Error of regression 0.299461			

Table: 6 Dynamic Ordinary Least Squares Estimates

Dynamic OLS Regression dependent variable is lnrer			
Var. Name	**Coefficient**	**Standard error**	**t-statistic**
lnETOT	-0.289**	0.133745	-2.164852
lnB-S	-0.28**	0.407104	-2.687716
NFA	-0.013***	0.005128	-2.657716
R-Squared 0.956083 Standard Error of regression 0.315678			

Source: Author's own estimates

Notes: ***, **, * indicates 1%, 5% & 10% level of significance.

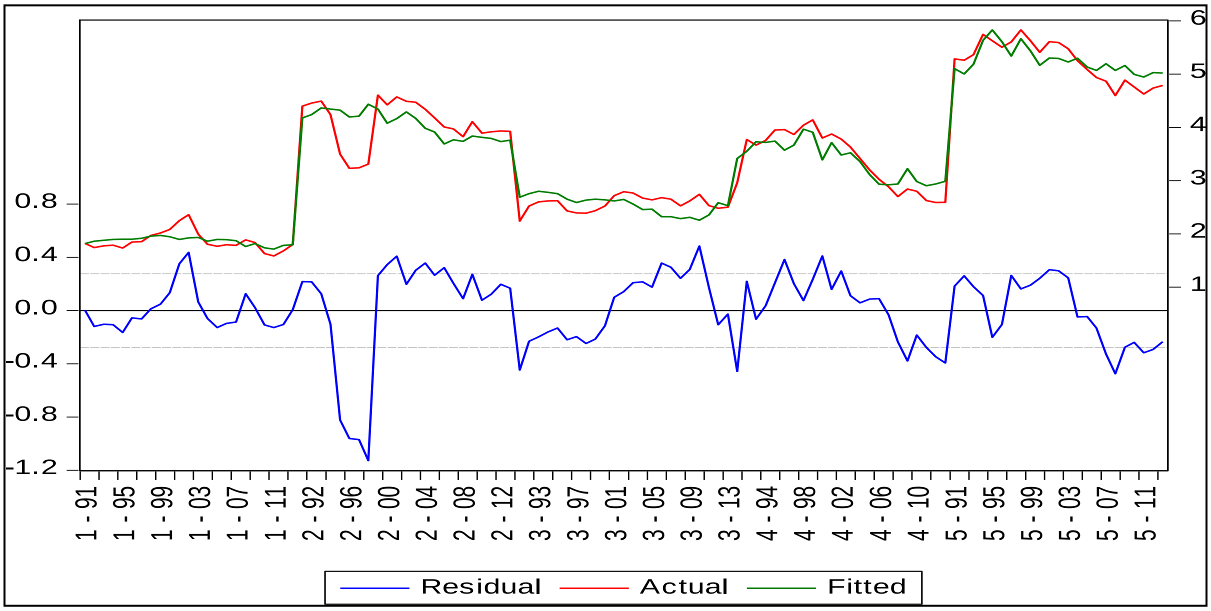
The results displayed in tables 5 and 6 are in line with the expectations of the signs established in chapter three. FMOLS suggests that a 10% improvement in Balassa-Samuelson (sectoral productivity) leads to 4.4% appreciation of the real exchange rate. It should be noted that a negative sign refers to real exchange rate appreciation whereas a positive sign refers to real exchange rate depreciation since an indirect method of quoting the exchange rate has been employed. A direct method of quoting the exchange rate is usually known as the price quotation. The exchange rate of the domestic currency is expressed as equivalent to a certain number of units of a foreign currency. The indirect method of quoting the exchange rate is generally known as quantity quotation. The exchange rate of a foreign currency is expressed as an equivalent number of a certain domestic currency. A 10% improvement in energy terms of trade leads to a 1.7% appreciation of the real exchange rate and this is statistically significant at all conventional levels of significance. Amano and van Norden (1995) found that an increase in oil prices led to the depreciation of the real exchange rate; that was due to the fact that the Canadian energy sector was highly regulated in order to protect domestic oil consumers from higher prices and due to the costs that are borne by other sectors when the energy price increases; this study therefore found this explanation not valid for Sub-Saharan African countries except for Angola whose currency depreciates by 0.45% following a 10% increase in energy prices. Unlike Canada, Sub-Saharan African countries do not have policies that endeavor to protect energy input users; therefore, an increase in energy prices directly affects users which will then translate into increased domestic prices, thus appreciating the domestic exchange rate. The net foreign asset position significantly affects the long-run equilibrium exchange rate, such that a 10% increase in net foreign asset position leads to a 0.11% appreciation of the real exchange rate. The suggestion that the exchange rate for Angola depreciates following an improvement in energy terms of trade poses a challenge to the monetary authorities. Nonetheless currency depreciation (if not excessive) could be preferred by some commentators simply because it attracts more exports since locally produced goods become cheaper than foreign-produced goods, reducing unemployment in the long run. The monetary authorities are then called upon to respond with the necessary tools to prevent their currency from losing excessive value following an increase in energy prices.

The dynamic OLS estimates suggest that a 10% improvement in sectoral productivity leads to a 2.8% appreciation of the real exchange rate, while a 10% increase in the net foreign asset position leads to a 0.13% appreciation of the real exchange rate. In line with the fully-modified OLS suggestion, a 10% improvement in energy terms of trade leads to a 2.9% appreciation of the real exchange rate and this is significant at all conventional levels of confidence. One would tend to rely on DOLS estimates as it has been noted previously that FMOLS have larger distortions relative to DOLS.

The dynamic OLS estimate suggests that energy price shocks have a strong impact on the real exchange rate for an energy producing country. A similar conclusion was drawn by Bodart *et al* (2012) who found that a 10% increase in the price of oil leads to a 3% appreciation of the exchange rate, and Coudert *et al* (2008) who found that a 10% increase in the price of oil leads to a 6.5% appreciation of the real exchange rate for an oil producing country.

This suggests that energy exporting countries are vulnerable to energy price shocks. Unlike Dauvin (2014) this study does not go on to estimate the points at which a currency becomes an 'energy currency' nor does it examine the impact of the exchange rate appreciation on other sectors of the economy. Nonetheless it worth noting that appreciation of the exchange rate could be unfavorable at times. If a country is open to foreign competition appreciation of the domestic exchange rate makes locally produced goods more expensive than foreign-produced goods; this affects the manufacturing sector which produces tradables by reducing the country's competitiveness. It is generally argued that an exchange rate appreciation usually generates a current account deficit because domestic consumers switch to cheap foreign-produced goods, causing more vulnerability in the domestic economy. Imports exceed exports, causing a rise in unemployment.

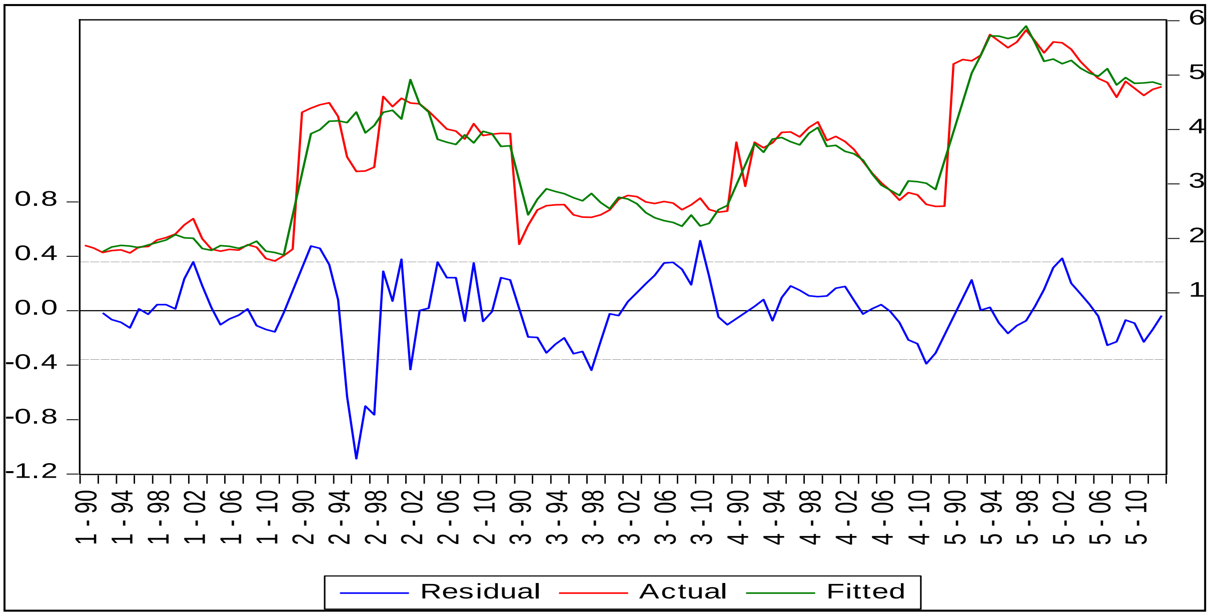
Figure: 6 FMOLS Residual, Actual and Fitted values



Source: Author’s own estimates

Figures 6 and 7 plot the actual real value of currencies against the values predicted by the equation and also plots the residuals. Figure 6 shows that the fit is remarkably close. The fit is extremely good for South Africa, especially from 2007 to 2011, and in Nigeria. The fundamentals explain the fall of currencies around 2007 -2011 as do the fitted values.

Figure: 7 DOLS Residual, Actual and Fitted values



Source: Author's own estimates

Figure 7 shows a good fit. It indicates that the fitted values have done a good job in explaining the movement of currencies, as do the actual values. Figures 6 and 7 agree with the r-squared values displayed in tables 6 and 7 which indicate that both models do a good job in explaining movements in the dependent variable.

4.3.Comparing the results

There has been growing consensus amongst scholars of economics that the terms of trade of a country have a strong impact on the exchange rate. Amano and van Norden (1995) pointed out that the impact of changes in the terms of trade could be very severe and more statistically significant if one isolates the energy terms of trade from other commodity terms of trade. Having said that, a number of studies followed Amano and van Norden's methodology and produced very mixed results. While some pointed out that an increase in energy prices leads to depreciation, others asserted that an increase in energy prices leads to appreciation of the exchange rate for an energy exporting country. The latter is consistent with economic theory. This section therefore compares the findings of this study with others in order to formulate policy recommendations, taking into account the heterogeneity across countries.

Contrary to what economic theory suggests, Amano and van Norden (1995) asserted that the Canadian dollar could not be classified as a ‘petro-currency’ since they found Canadian real exchange rate to depreciate in response to an improvement in energy terms of trade. This contradictory finding owes to policies that were in place and the costs borne by other sectors following an increase in oil prices.. It signaled a depreciation of the real exchange rate by 2.24% following a 1% increase in the price of energy. As has been shown in chapter two, many scholars such as Dauvin (2014), Coudert *et al* (2008), and Issa *et al* (2004), etc., found that energy prices had a positive effect on the real exchange rate. This study’s findings do not differ from previous findings in that it established that the exchange rate is indeed sensitive to the rise and fall of energy prices. However, Sub-Saharan African currencies cannot be classified as ‘energy currencies’ until further analysis has been performed to detect the point at which a currency becomes an energy currency. A number of studies, including Amano and van Norden (1995) have claimed that there is unidirectional causality running from energy terms of trade to exchange rate but not the other way round; hence, the next exercise examines the direction of the causality in the Sub-Saharan African context. It should be noted that this study’s findings are in line with the existing empirical evidence and resemble those of Dauvin (2014) and Coudert *et al* (2008).

4.4. Implications of the results

These findings are very informative and have vital implications for Sub-Saharan African energy exporting countries, as well as other developing countries. Since mid-2014, nominal energy prices have declined; thus, energy terms of trade are expected to deteriorate. If this is indeed the case, one would expect the currencies of energy exporting countries to depreciate in the near future; this has been evident in South Africa. The rand has lost value against other currencies such as the USD. While some might view this as a bad thing, others regard persistent depreciation as a good thing. Some people might prefer appreciation because they will be able to afford foreign-produced goods whereas other will prefer depreciation as it is generally argued that it would lead to improvement in the current account. Simply put, that would ultimately signal the competitiveness of the country.

Countries whose main source of revenue is energy input exports should therefore consider employing expansionary fiscal policy, thus reducing national savings and therefore, interest rates, so that they can generate permanent currency appreciation in order to counteract expected depreciation in energy exporting countries.

The decline in energy prices is favorable for many countries because many sectors of the economy (especially in developing economies) produce goods and are heavily dependent on energy for production. An increase in energy prices increases their costs of production, suppressing economic growth and production as a whole. This not only affects the growth and production of firms and the country, but also negatively impacts productivity and the rate of unemployment. Soaring production costs result in firms shutting down some of their machines and operations, reducing productivity as well as the number of people they employ.

Furthermore, a number of studies have been conducted on the so-called 'Dutch disease' effect. A rising exchange rate negatively impacts the manufacturing sector as this sector finds it very difficult to sell its products in global markets as the goods become more expensive relative to foreign products. Simply put, a rising real exchange rate significantly affects the profitability of other non-energy sectors, particularly the manufacturing sector. There is a still much debate among economists about an abundance of natural resources; some argue that resources are a curse while others maintain that they are a blessing. Not every country is disadvantaged by an abundance of resources. Countries such as Botswana show positive and strong growth in the presence of resources while others do not.

Nevertheless, an appreciating exchange rate could be a good thing for some economies, especially if the country is exporting a good which has no close substitutes. An appreciating exchange rate for an exporting country implies the redistribution of income and wealth from importing countries. A high value of the domestic currency basically means that exports are cheaper whereas imports are expensive. Because foreign countries will be paying high prices for domestically-produced goods or rather for energy inputs, they will be transferring a large portion of their incomes and wealth through high prices to the exporting country.

4.5. Granger Causality results

Almost all the existing empirical evidence, such as Amano and van Norden (1995, 1998), Bodart *et al* (2012), and Dauvin (2014), etc., suggests that the causality between the exchange rate and terms of trade is unidirectional, and runs from terms of trade to the real exchange rate rather than the other way round. This implies that an improvement in terms of trade requires the exchange rate to change in order to get back to the equilibrium state. However, terms of trade do not necessarily change as a result of the depreciation or appreciation of an exchange rate in order to maintain equilibrium. This section therefore examines the direction of the causality between the independent variables identified in this study and the exchange rate; the main interest being in the exchange rate and the terms of trade.

There is reason to believe that the direction of the causality may not necessary resemble the one found in the existing literature. This is due to the fact that existing studies mostly targeted advanced economies while this study specifically examines Sub-Saharan African countries. One would thus expect that, there will be huge exchange rates pass through given these countries' share of the international market.

Table 8 below shows the results of the Granger causality. Although it displays all four variables, the study will not go on to interpret all the other variables since the main interest is in the causality between the exchange rate and the energy terms of trade. At all conventional levels of significance one rejects the null hypothesis that energy terms of trade do not cause the real exchange rate. This is consistent with the existing literature that notes that energy terms of trade cause the real exchange rate. In contrast to the theory, the expectation that causality between the real exchange rate and the energy terms of trade run in both ways indeed hold. At 5% level of significance the null hypothesis of no Granger causality is rejected; hence, causality is bidirectional, and runs from the exchange rate to energy terms of trade and from energy terms of trade to the exchange rate.

Table: 7 Granger Causality Table

Null Hypothesis	**Obs**	**F-Statistic**	**Prob.**
lnREER does not Granger Cause lnTOT	90	0.53064	0.0334
lnETOT does not Granger Cause lnREER		1.16725	0.04526

Source: Author's own estimates

4.6.Conclusion

This chapter presented the findings of the study and the analysis. The findings were compared with the existing literature and it was found that they support this literature. The study found a significant relationship between energy terms of trade and the exchange rate. Furthermore, the Granger causality test suggests that there is a bidirectional causality running from both the exchange rate to energy terms of trade and from energy terms of trade to the exchange rate.

CHAPTER FIVE

CONCLUSION AND POLICY RECOMMENDATIONS

The study examined the impact of energy terms of trade, net foreign asset position, sector-wide productivity (Balassa-Samuelson effect) and real interest rate on equilibrium real exchange rates, for energy exporting Sub-Saharan African countries for the period 1995-2013. Consistent with theory and the existing empirical literature, it found that the domestic interest rate only has a transitory impact on the real exchange rate; hence, it was excluded from the long-run estimates. As a preliminary step in examining the exchange rate-fundamentals nexus, one has to examine the behavior of exchange rates, that is, whether or not they are mean reverting. If exchange rates are mean reverting, this implies that fundamentals do not have a significant impact on the long-run equilibrium exchange rate. Consistent with the existing literature, the study failed to reject the null hypothesis that real exchange rates are non-stationary (Cushman, 2008). Ultimately, the exchange rate is indeed determined by certain economic fundamentals in the long-run (Milesi-Ferretti, 2004, 2007 and MacDonald, 2006). The failure of PPP has serious policy implications for some economic models and African policy makers that rely on the assumption that PPP does hold (see Kargbo, 2003). The failure of PPP to hold indicates that, for countries that follow constant inflation rate policies or money growth rate rules, the value of their exchange rate becomes increasingly unpredictable the further into the future one goes (Darby, 1983). It is essential to examine PPP because if shocks are prolonged, this indicates that real factors are (may be) highly important for the determination of the exchange rate. Hence, policy makers would know what to target in order to maintain long-run exchange rate equilibrium.

It was found that there is indeed a long-run relationship between fundamentals and the real exchange rate, except for interest rates which were found to be stationary at levels. Hence, elasticities were estimated, and it was found that NFA, the Balassa-Samuelson effect and energy terms of trade significantly impact the long-run real exchange rate. FMOLS and DOLS suggested that a 10% increase in net foreign asset position appreciates the real exchange rate by 0.11% and 0.13%, respectively. The Balassa-Samuelsson effect appears to be highly important for the determination of the real exchange rate. A 10% increase in the Balassa-Samuelsson effect appreciates the real exchange rate by 4.4% and 2.8% as suggested by FMOLS and DOLS, respectively. Indeed, the study also finds in respect of its main objective support for the existence of energy currencies in energy exporting Sub-Saharan African countries. FMOLS and DOLS showed that a 10% increase in energy prices leads to 1.7% and 2.9% appreciation of the real exchange rate, respectively.

The study also supports the existing literature on the "Dutch disease". It was found that increasing energy prices tend to appreciate the real exchange rate; this is a necessary condition for the Dutch disease (Mohammadi and Jahan-Parvar, 2012). The first policy implication is that if high oil prices and gains from terms of trade are transitory, appropriate policy intervention is required to shield vulnerable industries, particularly manufacturing and infant industries. However, if the gains in terms of trade are enduring, appropriate policy action would take the form of major structural alterations that facilitate the reallocation of resources from the traditional exports sector to non-tradables, as well as diversification of the exports sector to make it less vulnerable to external shocks.

It is commonly accepted that the impact of prices on exchange rates is not linear; hence, it is suggested that future research examine this possibility. Dauvin (2014) asserted that a threshold value exists at which a currency becomes an energy currency. Ultimately, when energy prices are low, the exchange rate is not determined by energy terms of trade but the usual fundamentals, some of which were discussed in preceding sections. These include sector-wide productivity, net foreign asset position, etc. However, when energy prices are significantly high, the exchange rate follows an 'energy price' regime. Therefore it is highly recommended that future research examines such a threshold for Sub-Saharan African countries. It should be noted, however, that countries should be studied in isolation as they operate in totally different environments; the results might be biased if this is not taken into account.

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Appendices

Appendix A: Data Sources

Country	**Country Code**	**Real Interest Rate**	**Real Exchange rate**
South Africa	ZAF	FR.INR.RINR	PA.NUS.FCRF
Nigeria	NGA	FR.INR.RINR	PA.NUS.FCRF
Angola	AGO	FR.INR.RINR	PA.NUS.FCRF
Mozambique	MOZ	FR.INR.RINR	PA.NUS.FCRF
Republic of Congo	COG	FR.INR.RINR	PA.NUS.FCRF

Table: World Development indicators Data Sources

Country	**WEO Country Code**	**NFA**	**GDP PPP**	**Energy prices**	**GDP Deflator**
South Africa	**199**	BCA_NGDPD	PPPPC	PCOALSA	NGDP_D
Nigeria	**694**	BCA_NGDPD	PPPPC	POILAPSP	NGDP_D
Angola	**614**	BCA_NGDPD	PPPPC	POILAPSP	NGDP_D
Mozambique	**688**	BCA_NGDPD	PPPPC	PNGASJP	NGDP_D
Republic of Congo	**634**	BCA_NGDPD	PPPPC	POILAPSP	NGDP_D
United States	**111**	BCA_NGDPD	PPPPC	**… … … …**	NGDP_D

Table: World Economic Indicators IMF Data Sources

Appendix B: DATA

PANEL ID	YEARS	lnREER	lnB-S	NFA	RIR	lnETOT
1	1990	1.869685	-1.45459	1.379	4.74	-0.92998
1	1991	1.821417	-1.47286	1.178	3.96	-0.96269
1	1992	1.740267	-1.5381	1.504	3.78	-1.06799
1	1993	1.776865	-1.56137	2.13	2.72	-1.16725
1	1994	1.78939	-1.57744	0.012	5.47	-1.07668
1	1995	1.733698	-1.58279	-1.65	6.93	-0.95818
1	1996	1.844026	-1.58579	-1.151	10.58	-0.98939
1	1997	1.852387	-1.60971	-1.492	11.00	-1.00812
1	1998	1.970994	-1.65297	-1.764	13.07	-1.11893
1	1999	2.016786	-1.68041	-0.511	10.20	-1.20013
1	2000	2.082271	-1.68187	-0.129	5.23	-1.09673
1	2001	2.24659	-1.68258	0.281	5.67	-0.81598
1	2002	2.362174	-1.66841	0.827	4.52	-1.06799
1	2003	1.996188	-1.67053	-0.99	8.91	-0.97354
1	2004	1.803551	-1.66651	-3.035	4.63	-0.44143
1	2005	1.766443	-1.64719	-3.469	4.91	-0.64112
1	2006	1.796281	-1.62266	-5.307	4.35	-0.57322
1	2007	1.784432	-1.58968	-6.971	4.71	-0.42092
1	2008	1.885957	-1.55513	-7.174	6.59	0.159288

1	2009	1.838617	-1.54668	-4.031	3.08	-0.39963
1	2010	1.63072	-1.54619	-1.968	2.03	-0.08749
1	2011	1.58484	-1.53538	-2.322	2.95	0.065809
1	2012	1.68139	-1.54474	-5.242	4.11	-0.14603
1	2013	1.801678	-1.55102	-5.824	2.51	-0.14603
2	1990	4.315571	-3.16569	7.619	14.65	-1.28785
2	1991	4.395498	-3.18621	-1.187	2.07	-1.44906
2	1992	4.455943	-3.23071	-4.343	-25.77	-1.48318
2	1993	4.490715	-3.25121	-12.038	4.37	-1.64093
2	1994	4.238528	-3.29675	-8.12	-8.03	-1.65946
2	1995	3.498094	-3.34198	-4.252	-43.57	-1.67491
2	1996	3.232571	-3.346	4.146	-9.71	-1.48727
2	1997	3.239529	-3.39492	4.785	16.61	-1.49486
2	1998	3.308646	-3.40971	-9.244	25.28	-1.83817
2	1999	4.605009	-3.46803	-3.949	2.77	-1.50018
2	2000	4.42222	-3.47242	12.474	-10.32	-1.03599
2	2001	4.573012	-3.42025	4.601	23.84	-1.14659
2	2002	4.48816	-3.26315	-13.013	-10.81	-1.10964
2	2003	4.471394	-3.2101	-5.938	8.61	-1.0137
2	2004	4.337905	-3.16114	5.648	19.37	-0.81175

2	2005	4.176864	-3.20399	8.737	-2.63	-0.49709
2	2006	4.008406	-3.18774	25.335	-0.37	-0.33589
2	2007	3.970183	-3.15532	16.529	11.61	-0.29402
2	2008	3.825872	-3.11214	14.004	4.19	-0.0581
2	2009	4.106652	-3.03489	8.189	23.71	-0.4456
2	2010	3.890742	-3.00239	5.795	-42.31	-0.23534
2	2011	3.916189	-2.96975	3.53	5.94	-0.04587
2	2012	3.930981	-2.95346	7.738	6.88	-0.02374
2	2013	3.925716	-2.9314	4.694	10.25	-0.01895
3	1990	1.890779	-4.5558	-11.998	1.17	-3.71219
3	1991	2.240248	-4.49715	-11.357	6.73	-1.44906
3	1992	2.523155	-4.59112	-13.071	2.23	-1.48318
3	1993	2.601287	-4.54235	-16.48	12.96	-1.64093
3	1994	2.617632	-4.53729	-14.724	16.53	-1.65946
3	1995	2.622294	-4.55575	-11.619	18.76	-1.67491
3	1996	2.431268	-4.4691	-8.654	6.26	-1.48727
3	1997	2.391828	-4.42027	-4.955	10.89	-1.49486
3	1998	2.387769	-4.36031	-6.382	17.99	-1.83817

3	1999	2.434477	-4.33534	-13.472	14.61	-1.50018
3	2000	2.523305	-4.37158	-17.872	6.26	-1.03599
3	2001	2.717613	-4.28267	-18	6.83	-1.14659
3	2002	2.790667	-4.23022	-23.131	16.94	-1.10964
3	2003	2.768367	-4.21378	-17.438	18.51	-1.0137
3	2004	2.671525	-4.20834	-11.624	14.52	-0.81175
3	2005	2.639946	-4.20197	-17.215	10.11	-0.49709
3	2006	2.677762	-4.16266	-8.631	6.10	-0.33589
3	2007	2.649886	-4.12691	-10.924	11.30	-0.29402
3	2008	2.527565	-4.07495	-12.92	9.19	-0.0581
3	2009	2.618828	-4.00239	-12.241	11.06	-0.4456
3	2010	2.741497	-3.97667	-11.656	5.23	-0.23534
3	2011	2.529279	-3.94324	-24.378	10.38	-0.04587
3	2012	2.480523	-3.91895	-45.593	12.02	-0.02374

3	2013	2.501197	-3.88617	-41.921	9.32	-0.01895
4	1990	3.768286	-2.40552	0.013	-48.53	-1.28785
4	1991	2.958235	-2.40925	-1.199	-38.35	-1.44906
4	1992	3.7689	-2.51869	-8.206	-42.07	-1.48318
4	1993	3.665324	-2.83457	-9.529	3.86	-1.64093
4	1994	3.753226	-2.87631	-6.479	-30.89	-1.65946
4	1995	3.948277	-2.77916	-12.06	-84.65	-1.67491
4	1996	3.956786	-2.6579	-4.827	-94.22	-1.48727
4	1997	3.86758	-2.66489	-12.486	-29.11	-1.49486
4	1998	4.03948	-2.72536	-31.275	7.16	-1.83817
4	1999	4.141135	-2.75794	-29.842	-72.56	-1.50018
4	2000	3.798746	-2.78619	9.434	-60.80	-1.03599
4	2001	3.873769	-2.78328	-17.327	-5.02	-1.14659
4	2002	3.778405	-2.6843	-1.431	-18.62	-1.10964
4	2003	3.631214	-2.69878	-5.592	6.07	-1.0137
4	2004	3.415758	-2.65099	3.76	30.43	-0.81175
4	2005	3.197123	-2.58672	18.196	32.25	-0.49709
4	2006	3.02369	-2.44309	25.629	5.72	-0.33589

4	2007	2.884438	-2.27414	19.944	4.51	-0.29402
4	2008	2.702066	-2.15873	10.326	-5.97	-0.0581
4	2009	2.84248	-2.12391	-9.93	24.95	-0.4456
4	2010	2.799613	-2.13707	8.103	0.12	-0.23534
4	2011	2.624434	-2.13939	12.567	-4.36	-0.04587
4	2012	2.590022	-2.13871	9.222	9.00	-0.02374
4	2013	2.591169	-2.14005	4.961	12.97	-0.01895
5	1990	5.203981	-2.19309	22.297	14.68	-1.28785
5	1991	5.287143	-2.18541	4.127	19.92	-1.44906
5	1992	5.261786	-2.21169	14.519	19.65	-1.48318
5	1993	5.364125	-2.2655	2.892	18.80	-1.64093
5	1994	5.745509	-2.37887	-31.521	-14.08	-1.65946
5	1995	5.626324	-2.38377	-48.044	12.19	-1.67491
5	1996	5.503509	-2.36736	-32.325	3.40	-1.48727
5	1997	5.603911	-2.43417	-6.283	16.23	-1.49486
5	1998	5.826582	-2.45794	-28.509	49.18	-1.83817
5	1999	5.626082	-2.54858	-10.104	-5.69	-1.50018
5	2000	5.408308	-2.53319	5.951	-17.03	-1.03599

5	2001	5.610054	-2.52361	-4.775	40.19	-1.14659
5	2002	5.592422	-2.51522	-4.763	20.09	-1.10964
5	2003	5.473985	-2.55386	0.935	23.24	-1.0137
5	2004	5.250212	-2.48902	-10.581	1.02	-0.81175
5	2005	5.0869	-2.51779	0.444	-3.02	-0.49709
5	2006	4.938545	-2.50274	2.826	-2.69	-0.33589
5	2007	4.866467	-2.55512	-6.507	13.72	-0.29402
5	2008	4.594547	-2.5173	-0.55	12.91	-0.0581
5	2009	4.886246	-2.43675	-6.013	-7.53	-0.4456
5	2010	4.757738	-2.39863	3.825	-3.93	-0.23534
5	2011	4.627538	-2.40489	5.774	13.72	-0.04587
5	2012	4.735672	-2.41641	-1.293	-5.69	-0.02374
5	2013	4.787131	-2.40552	-1.229	10.07	-0.01895