An Empirical Analysis of the Determinants of Exchange Rate in Selected Sub-Saharan African Countries Using Single-Country Estimation Techniques

Abstract:

Exchange rate has become a buoyant issue in a globalised world where countries compete with each other to sustain growth and development. Despite the importance of exchange rate in sustaining economic growth and development in Sub-Saharan African (SSA) countries, empirical analyses in these countries are quite sparse. Research done in this area focusing on each of these countries remains more fairly limited. Hence, this study aims at investigating the determinants of exchange rate in selected Sub-Saharan African countries using single-country estimation techniques. In particular, an autoregressive distributed lag (ARDL) model is employed to examine the determinants of exchange rate in nine SSA countries using annual data spanning from 1980 to 2013. Our findings show that the long-run and short-run relationships between exchange rate and its determinants rely upon the country investigated.

Keywords: Determinants; Exchange Rate; Sub-Saharan Africa; ARDL; Single-Country Estimation.

1. Introduction

The management of exchange rate remains one key international macroeconomic issue and has been investigated within both the theoretical and empirical lenses. The foreign exchange rate market is, without doubt, one of the largest financial markets in a globalised world, where countries compete with each other to sustain growth and development. Indeed, many researchers have highlighted the importance of exchange rate (see Cottani et al., 1990; Ghura and Grennes, 1993; Elbadawi et al., 2012).

It is generally agreed that the main objective of any exchange rate policy should be to correct the real exchange rate misalignment. Misalignment in the real exchange rate occurs when the actual (observed) exchange rate deviates from equilibrium exchange rate (Edwards, 1989). Indeed, most governments care about the equilibrium of the real exchange rate of their currency since this is directly related to the appreciation and depreciation of their home country's currency. For example, a rise in the real exchange rate favours imports, since foreign goods are cheaper than domestic goods. But, likewise, this rise represents a problem for exporters, whose goods become less competitive in the global markets. Real exchange rate misalignment is also a serious problem in many developing countries. In the specific case of Sub-Saharan African

countries, Ghura and Grennes (1993) obtained empirical evidence of the negative impact of real exchange rate misalignment on economic growth. Moreover, Elbadawi et al. (2012) found that an overvaluation in real exchange rate affects growth by decreasing it. Furthermore, Bleaney and Greenaway (2001) concluded that investment is negatively affected by real exchange rate instability. Thus, it is important to understand the factors that cause developments in the exchange rate.

Prior to the calculation of the misalignment that occurs in the real exchange rate, policy makers use different models to estimate the equilibrium exchange rate. In literature, two distinct approaches have been used to analyse the developments in the real exchange rate. The first approach is based on conventional structural models such as the Purchasing Power Parity (PPP) model, Covered Interest Rate Parity (CIP), Uncovered Interest Rate Parity (UCIP) model, monetary models (flexible monetary models, sticky-price monetary models, Mundell-Fleming models) and portfolio balance models. The second one is based on equilibrium exchange rate models in which the equilibrium exchange rate is considered to be driven by a set of variables. Among these include: the Behavioural Equilibrium Exchange Rate (BEER) model, the Permanent Equilibrium Exchange Rate (PEER) model, the Capital Enhanced Equilibrium (CHEER) model, the Fundamental Equilibrium Exchange Rate (FEER) model and the Natural Real Exchange Rate (NATREX) model.

These models have been used according to the different time horizons: short-run, medium-run and long-run. For instance, the Uncovered Interest Rate Parity (UIP) model, the Capital Enhanced Equilibrium Exchange Rates (CHEERs) model, the Behavioural Equilibrium Exchange Rates (BEERs) model and monetary models are mostly appropriate for estimating the short run equilibrium exchange rates while other models, such as Purchasing Power Parity (PPP) model, Balassa-Samuelson (BS) model and the Permanent Equilibrium Exchange Rates (PEERs) model, better estimate the latter in the long run. Moreover, other models that take into account both the internal and external balance of a country have also been developed to measure the equilibrium exchange rates at different time horizons. For example, the Fundamental Equilibrium Exchange Rates (FEERs) model can be used to measure the equilibrium exchange rate in the medium run whereas the Natural Real Exchange Rates (NATREX) model can be employed to model the long run equilibrium exchange rate. Edwards (1988) was the first one to model the equilibrium real exchange of some developing countries using a set of fundamentals which take into account both the internal and external equilibrium of a country. Following Edwards' pioneering work, empirical studies have used different set

of variables to estimate the equilibrium real exchange rate. Both single country and panel investigations have been carried out.

Both approaches have shown that there are different factors that cause fluctuations in the exchange rate. Many studies have concluded that both real and nominal shocks affect the behaviour of the exchange rate over time, causing its fluctuations. Among these factors are the monetary factors, productivity shocks, changes in government spending and consumption, terms of trade shocks, changes in exchange and capital controls, labour supply shocks, changes in interest rates, changes in inflation, changes in debt services, changes in investment amongst others. Moreover, due to the unavailability of data on the real exchange rate, different measures have also been used to model this series. Among these measures are: nominal effective exchange rate, nominal exchange rate, real exchange rate, real effective exchange rate and bilateral exchange rate.

Although exchange rate is important in sustaining economic growth and development, especially in Sub-Saharan African countries, empirical analyses in these countries are quite sparse. Hence, this study aims at examining the determinants of exchange rate in these countries. The long-run and short-run determinants of exchange rate in SSA countries were only investigated within a panel data setting. Additionally, the price level has not been included in these models. Thus, this study somehow demarcates from previous empirical studies on the topic in that it attempts to examine the determinants of exchange rate in selected SSA countries by focusing on each one of them instead of employing a panel data framework for analysis. Moreover, the effect of price level on exchange rate has also been taken into account in our analysis. The remainder of this paper is structured as follows: The next section reviews the empirical literature on the determinants of exchange rate. This is followed by a brief discussion of the data and methodology used in Section 3. Section 4 presents and discusses the empirical results. The last section provides some conclusions drawn from the results obtained.

2. Literature Review

A considerable amount of literature has been published on the determinants of exchange rate. However, due to unavailability of appropriate data, consensus has not been formed on an appropriate model for a given country or time horizon. In this section, a review of two strands of the literature is presented: firstly, studies and research conducted on a particular country, and secondly, those studies which have considered a set of countries for investigation.

2.1 Evidence from single country estimations

Aron et al. (1997) investigated both the short-run and long-run determinants of the quarterly real exchange rate of South Africa using a Cointegration framework and single equation equilibrium correction model. Trade openness, government expenditure, non-gold terms of trade and the real price of gold were found significant both in the long-run and short-run. In his study, De Jaher (2012) also indicated that the real effective exchange of South Africa was appreciated by productivity differential, real interest rate differential and capital flows and trade openness depreciated the latter. Recently, within the autoregressive distributed lag (ARDL) bounds testing procedure, Njindan Iyke and Odhiambo (2015) found that terms of trade, trade openness, government consumption, net foreign assets and real commodity prices were the long-run determinants of the real exchange rate in South Africa for the period 1975-2012.

For the specific case of Botswana, Iimi (2006) found that an improvement in terms of trade, real interest rate differential was accompanied by an increase in the real effective exchange rate of Botswana and net foreign asset by a decrease. Njindan Iyke and Odhiambo (2016), who employed the ARDL bounds testing procedure, also concluded that terms of trade and trade openness were potential drivers of the equilibrium real exchange rate for Botswana in both the short-run and long-run. Moreover, for Sierra Leone, the findings of Tarawalie (2010) within the error correction framework, revealed that the real effective exchange rate of Sierra Leone was positively influenced by investment and nominal effective exchange rate, and negatively by terms of trade and excess credit. In a similar vein, Korsu and Braima (2011) found that in the long-run, the real exchange rate of Sierra Leone was appreciated by investment, real GDP, government expenditure and depreciated by capital inflow and terms of trade. In the short-run, their findings indicated that an increase in price level, capital inflow, capital accumulation and trade restrictions led to the appreciation of the latter while output and nominal exchange rate to its depreciation.

On the other hand, studies focusing on Mauritius include Imam and Minoiu (2011) and Njindan Iyke (2015). Imam and Minoiu (2011) assessed the equilibrium of the Mauritian rupee in 2006-2007 and over the medium run using two structural models: the Macroeconomic Balance (MB) approach and the Fundamental Equilibrium Exchange Rate (FEER) approach. Their results suggested that the Mauritian rupee was aligned with its equilibrium value in 2006-2007 and little adjustment appeared necessary over the medium run. Njindan Iyke (2015) examined the potential determinants of the real exchange rate in Mauritius using the Bayesian Model

Averaging (BMA) method, and concluded that real money supply negatively influenced the real exchange rate whereas real productivity positively.

The results from Hyder and Mahboob (2006) revealed that in the long-run, the real effective exchange rate of Pakistan was positively affected by terms of trade, workers' remittances and total factor productivity and negatively by trade openness, government expenditure and capital inflows. Trade openness, government expenditure and capital inflows were found to affect the short-run dynamics of the real exchange rate in the same direction as they did in the long-run while the others were insignificant. Similarly, Bashir and Luqman (2014) also concluded that the real exchange rate of Pakistan was appreciated by an improvement in terms of trade and worker's remittances and depreciated by trade restrictions. Nevertheless, the price level variable was found to be insignificant.

The findings from Mongardini (1998) indicated that terms of trade, government consumption and technological progress had a positive impact on the real effective exchange rate of Egypt while debt service and capital account had a negative one. Alper and Saglam (1999) showed that the real exchange rate of Turkey was appreciated by terms of trade and depreciated by interest rate and trade openness in the long-run. Chowdhury (1999) employed annual data (1970 – 1994) to examine the determinants of real exchange rate in Papua New Guinea. Both real and nominal variables - Terms of trade, share of government expenditure to Gross Domestic Product (GDP), net capital inflow, foreign aid and grant, trade restrictions, measure of technological progress, nominal devaluation, domestic credit and excess supply of domestic money supply - have been considered. The results showed that real variables influenced the long-run equilibrium value of the real exchange rate while both real and nominal variables had an effect on the real exchange rate in the short-run.

Mkenda (2001) also analysed the long-run and short-run determinants of three real exchange rates in Zambia, namely the real exchange rates for imports and exports and the internal real exchange rate, for the period covering 1965 to 1996. They found that in the long-run terms of trade, investment share and government consumption determined the real exchange rate for imports, and terms of trade, central bank reserves and trade taxes had an impact on the real exchange rate for exports. For the internal real exchange rate, terms of trade, investment share and the rate of growth of real GDP were found to be the long-run determinants and the flow of aid and real money supply as the short-run determinants. Moreover, nominal exchange rate and openness had short-run effects on the real exchange rates for exports and imports. Mathisen

(2003) indicated that the real effective exchange rate of Malawi was affected positively by terms of trade and negatively by government consumption, investment and net foreign assets.

Eita and Sichei (2006) showed that an increase in trade openness and investment led to the appreciation of the real effective exchange rate of Namibia while terms of trade was insignificant. López Villavicencio and Bara (2008) examined the short run and long run dynamics of the real exchange rate of Mexico. Their findings revealed that a rise in productivity, interest rate differential and capital account led to the appreciation of the real exchange rate in the long-run and in the short-run, while productivity was insignificant, the same effect was observed for the interest rate differential and the capital account. Jayaraman and Choong (2011) showed that trade openness had a negative impact on the real exchange rate of Fiji while net foreign assets and government expenditure proved to have a positive one. Baak (2012) found that net foreign assets, real interest rate differential caused an increase in the real effective exchange rate of Korea while terms of trade a decrease. The Error Correction Model (ECM) results from Oriavwote and Oyovwi (2012) showed that in the short-run, the ratio of government spending to GDP, terms of trade and technological progress were not important determinants of the real effective exchange rate of Nigeria while capital flow, price level and nominal effective rate proved to be important.

Atif et al. (2013) analysed the determinants of the bilateral exchange rate AUD$/US$ over the period 1975 to 2012 using six indicators: Gross Domestic Product (GDP), interest rate, capital account balance, money supply, inflation and net exports. Trade components and macroeconomic indicators such as output and liquidity relative to the US proved to be significant in determining the exchange rate AUD$/US$ while interest rates and inflation were insignificant. Kia (2013) developed a theoretical monetary model for the real exchange rate of Canada. His results showed that all variables, with the exception of real money supply, domestic and foreign interest rate and domestic externally financed debt, had significant impact on the real exchange rate in Canada. However, the domestic fiscal variables did not affect the real exchange rate over the short run. Changes in the interest rate, the growth of money supply, the commodity price and the US debt per GDP had a negative impact on the real exchange rate over the short-run. Upon investigating the determinants of the HUF/USD exchange rate, Hsing (2016) concluded that a higher interest rate, more real GDP, a higher stock market index and a lower inflation rate in Hungary caused the HUF/USD to depreciate while a higher interest rate, more real GDP, a higher stock price index and a lower inflation rate in the U.S. led to its depreciation.

2.2 Evidence from panel data estimations

On the other hand, very few researchers have investigated the determinants of exchange rate within a panel data framework. Edwards (1988) was the first to investigate the determinants of exchange rate for a panel of developing countries in order to estimate the equilibrium value of the real exchange rate in these countries. According to his estimations, terms of trade, technological progress, capital inflows, nominal devaluation, excess domestic credits and government consumption were among the most important variables influencing exchange rate in these countries. This was followed by an array of applied studies examining the determinants of exchange rate in order to provide an estimation of the equilibrium level of the latter. Bothe developed and developing countries have been investigated.

Drine and Rault (2003) examined the long-run determinants of real exchange rate for a sample of 45 developing countries. The study revealed that an improvement in terms of trade, an increase in per capita GDP and capital flows resulted in a long-run appreciation of the real exchange rate while an increase of the domestic investment and of the openness degree of the economy resulted in the real exchange rate depreciation. Dufrénot and Yehoue (2005) used panel co-integration techniques and common factor analysis to analyse the relationship between the real exchange rate and its determinants in a sample of 64 developing countries. This sample was further divided into three subgroups: low-income countries, lower middle-income countries and upper middle-income countries. The dynamics of the real exchange rate were studied with their economic fundamentals namely productivity, the terms of trade, openness, and government spending. Empirical results showed that some fundamentals such as productivity, terms of trade, and openness were strongly related to the common factors in low-income countries. However, for middle-income countries, the real exchange rate dynamics appeared to be governed by heterogeneity. Recently, Nouira and Sekkat (2015) explored the determinants of the real exchange rate of developing countries and concluded that productivity and government consumption were associated with an increase in the real exchange while capital inflow, trade openness, debt services and terms of trade with a decrease. Drine and Rault (2015) examined the long-run determinants of real exchange rates for a sample of 45 developing countries. His investigations showed that the degrees of development and openness of the economy strongly affect the real exchange rate.

Kim and Korhonen (2005) found that the real effective exchange rate of transition economies were driven by terms of trade, the GDP per capita, investment, government consumption and trade openness. They all led to the appreciation of the real effective exchange rate with the

exception of trade openness. Moreover, Boero et al. (2015) showed that in transition economies, an increase in productivity, capital account and interest rate differential induced an appreciation of the real exchange rate of the latter in the long-run.

Carrera and Restout (2008) identified six fundamentals to have potential effect on the long-run behaviour of the real exchange rates of nineteen countries of Latin America over the period 1970 - 2006: the Balassa-Samuelson effect, government spending, terms of trade, the country's openness to international trade, foreign capital inflows and net foreign assets. In particular, a higher government spending to GDP ratio, an increase in productivity differential, a positive terms of trade shock, a surge in foreign capital flows and a higher net foreign assets position were found to affect positively the real exchange rate whereas an increase in trade openness led to its depreciation. The findings from Tsen (2011) revealed that productivity differential, terms of trade, the real oil price, and reserve differential were important determinants of the real exchange rate of Asian economies in the long-run.

Despite being more fairly limited in the literature, studies have also been carried out in Sub-Saharan African (SSA) countries. Among these feature: Ghura and Grennes (1993), Chudik and Mongardini (2007), Ouattara and Strobl (2008), Gnimassoun (2012), Elbadawi et al. (2012) and Couharde et al. (2012). Ghura and Grennes (1993) found that terms of trade, closeness, capital inflow, excess domestic credit and nominal devaluation were the major factors that caused fluctuations in the real exchange rate for a sample of 33 SSA countries. In a similar vein, Chudik and Mongardini (2007), who estimated the equilibrium real exchange rates for a sample of 36 Sub-Saharan African countries using both single-country and panel estimation techniques, concluded that the equilibrium level of real exchange rate in these countries were affected by changes in GDP, openness, terms of trade and government consumption. Moreover, the findings from Ouattara and Strobl (2008) indicated that official development assistance, terms of trade and government consumption led to the appreciation of the real effective exchange rate while trade openness and investment to its depreciation. The same was found by Gnimassoun (2012). The empirical results of Couharde et al. (2012) also indicated that terms of trade, productivity, government consumption and net foreign assets had a positive impact on the real exchange rate. The findings from Elbadawi et al. (2012) revealed that the real exchange rates of 29 SSA countries were positively influenced by terms of trade, productivity and foreign aid, and negatively by trade openness.

3. Methods

3.1 Empirical model

In an attempt to present a dynamic model for the determinants of the exchange rate in selected SSA countries, it is necessary to specify an empirical equation that includes both real and nominal variables together by considering both the internal and external equilibria of the countries. Based on previous empirical studies, the following relationship has been established:

$$REER = f(FUNDAMENTALS) \quad (1)$$

where $REER$ is the real effective exchange rate of the home country, and $FUNDAMENTALS$ consist of a set of potential determinants of exchange rate used in literature: terms of trade (TOT), trade openness (OPEN), real GDP per capita (GDP), investment (INV), government consumption (GOV), inflation rate (INF), official development assistance (ODA), net foreign assets (NFA) and money supply (MS).

Description of variables:

Conventionally, due to unavailability of time series data for some variables, relevant proxies have been employed to measure the latter. Their construction is explained below:

Real effective exchange rate (REER)

In an attempt to better assess the country's trade capabilities and its current import and export situations, the real effective exchange rate has been used as a measurement of the country's exchange rate. It is defined as the ratio of the consumer price index (CPI) of the home country to the geometrically weighted average of the consumer price indices of trading partners multiplied by the nominal effective exchange rate of home country. An increase in the real effective exchange rate index implies an appreciation of the home country's currency against the basket of currencies of trading partners.

Terms of trade (TOT)

The terms of trade is defined as the ratio of the price of a country's exports over the price of its imports. For example, if the price of a country's exports rises by a greater rate than that of its imports, this improves its terms of trade. This, in turn, results in rising revenues from exports, which increases the demand of the country's currency. Thus, an improvement in terms of trade will positively affect the trade balance and lead to the appreciation of the exchange rate. On the other hand, if the price of exports rises by a smaller rate than that of its

imports, the country's currency's value will decrease in relation to its trading partners. Hence, this results in the depreciation of the exchange rate. Many empirical studies have shown that an improvement in terms of trade leads to the appreciation of the exchange rate (see Drine and Rault, 2003; Ghura and Grennes, 1993; Dufrénot and Yehoue, 2005). In this study, the net barter terms of trade, defined as the percentage ratio of the export unit value indexes to the import unit value indexes, has been used.

Trade openness (OPEN)

Trade openness is used as an indicator of trade policy restrictions such as tariffs and quotas. It is defined as the ratio of the sum of imports and exports of goods and services measured as a share of gross domestic product. Protection of domestically produced goods via restrictions on cross-border trade (for instance, import tariffs and non-tariff barriers) leads to higher domestic prices and thus to the appreciation of the exchange rate. Consequently, lifting existing trade restrictions (proxied by an increase in trade openness) should cause the exchange rate to depreciate.

Real GDP per capita (GDP)

Following Edwards (1989) and previous empirical studies on developing countries, this variable has been used to capture the productivity effect on exchange rate. The productivity effect refers to the Balassa-Samuelson effect. According to this hypothesis, productivity leads to an appreciation of the home country's exchange rate.

Investment (INV)

This variable refers to the ratio of total investment to GDP. An increase in the ratio of investment to GDP will increase absorption. As a result, this will worsen the current account and leads to the depreciation of exchange rate. However, some empirical studies noted that the expected sign is unclear as including investment in the theoretical model results in supply-side effects, which are dependent on the relative factor intensities across sectors (see Edwards, 1988; Mathisen, 2003; Chudik and Mongardini, 2007).

Government consumption (GOV)

Since, we cannot decompose public spending into public spending in tradable and non-tradable sectors, this variable is used to capture the influence that public spending in the non-tradable goods has on the real effective exchange rate. Due to the unavailability of data on the latter, the general government final consumption expenditure as a percentage of GDP has

been employed as a proxy to measure it. An increase in government consumption means that there is higher demand for the non-tradable sector as compared to the tradable one, and as a result, this boosts the relative prices of non-tradable goods, causing exchange rate to appreciate.

Inflation rate (INF)

This variable refers to the rate of inflation, measured as the annual percentage of consumer prices. It has been used to capture the effect of price level on exchange rate. Based on most previous theories and empirical studies, an increase in inflation rate results in the depreciation of the real effective exchange rate.

Official development assistance (ODA)

The net official development assistance as a ratio of GDP has been used as a proxy for aid flows. According to the "Dutch disease" hypothesis, an increase in aid flows will lead to the appreciation of the exchange rate. However, for the case of middle-income countries, the opposite was found. In other words, aid flows are associated with exchange rate depreciation.

Net foreign assets (NFA)

This variable refers to net foreign assets as a share of GDP, used as a proxy for the country's net external position. An increase in capital inflows from abroad leads to a higher demand for domestic currency. As a result, exchange rate appreciates.

Money supply (MS)

According to the monetary model of exchange rate determination developed by Frenkel (1976), an increase in money supply causes exchange rate to depreciate. This is also supported by empirical studies conducted using the monetary approach of exchange rate determination (see Kia, 2013 and Shevchuk, 2014). Due to unavailability of data on money supply, this study employs broad money as a percentage of GDP as a measurement of money supply.

3.2 Data

We consider a sample of nine SSA countries namely: Botswana, Cameroon, Central African Republic, Ghana, Kenya, Madagascar, Nigeria, Senegal and South Africa. The sample period is based on annual data spanning from 1980 to 2013 (34 years). The real effective exchange rate data was obtained from www.bruegel.org. Data on investment as a percentage of GDP was extracted from the International Monetary Fund World Economic Outlook (WEO) database while the others from the World Development Indicators database of World Bank.

In an attempt to examine the determinants of the real effective exchange rate and its elasticities with respect to the various factors considered, this study follows a log-log model. Taking logs on both sides of equation (1) above results in the following specification:

$$reer_t = \beta_0 + \sum_{i=1}^{n} \beta_i fundamental_{it} + \varepsilon_t \quad (2)$$

where subscript *t* represents time indexes, $fundamental_{it}$ represent the set of potential determinants of the real effective exchange rate of the country investigated, β_i is the coefficient of the respective determinant, and β_0 and ε_t are the intercept and disturbance terms. From now onwards, small letters denote the logarithmic form of the variables.

4. Results and discussions

4.1 Unit root test results

As a preliminary analysis, prior to estimating the determinants of the real effective exchange rate of the above-mentioned SSA countries, we examined the stationary properties and order of integration of the above-mentioned fundamentals for all countries. As such, all variables in our proposed model have been tested for unit roots using both the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests. The tests have been conducted with both an intercept, and an intercept and trend. The findings indicated that at the 10% significance level some variables are stationary at level, and some are not stationary at level and become stationary after taking first difference. In other words, our model consists of a mixture of both **I(0)** and **I(1)** variables.

4.2 Cointegration test results

Since we have a mixture of both **I(0)** and **I(1)**, we employ the autoregressive distributed lag (ARDL) bounds testing approach to check whether there is a valid long-run relationship among the variables. Before testing for cointegration, it is important to determine the lag length of the ARDL model to be estimated. The optimum lag lengths for the selected model for each country were selected based on the Schwarz information criterion (SIC). For instance, an ARDL(1, 1, 1, 1, 1, 1) for Central African Republic represents an ARDL model in which the *reer*, *tot*, *open*, *gdp*, *inv* and *oda* take the lag length 1, 1, 1, 1, 1, 1 respectively. Table 1 summarises the results of the cointegration test based on bounds testing approach. It can be observed that for all models, the *F*-statistics fall outside the upper bound and are statistically significant. The null hypotheses of no cointegration are thus rejected for all

models, and this implies that there are long-run relationships among the variables included in the proposed model for each country.

Table 1: ARDL Bounds F-Test for Cointegration - Unrestricted intercept and no trend

Model Selection	$k^{\#}$	F-Statistic	Bounds	Cointegration
Botswana: ARDL(1, 0, 0, 1, 0, 1, 1)	6	4.3999**	I(0) - I(1) = 2.45 - 3.61	Present
Cameroon: ARDL(1, 3, 0, 2, 3, 2)	5	4.6044**	I(0) - I(1) = 2.62 - 3.79	Present
Central African Republic: ARDL(1, 1, 1, 1, 1, 1)	5	4.4569**	I(0) - I(1) = 2.62 - 3.79	Present
Ghana: ARDL(3, 2, 3, 0, 0)	4	8.4446***	I(0) - I(1) = 3.74 - 5.06	Present
Kenya: ARDL(1, 2, 1, 2, 0, 1, 2)	6	4.3490**	I(0) - I(1) = 2.45 - 3.61	Present
Madagascar: ARDL(2, 2, 2, 2, 1, 3, 1)	6	6.6846***	I(0) - I(1) = 3.15 - 4.43	Present
Nigeria: ARDL(1, 1, 0, 1, 2, 0, 1)	6	6.3993***	I(0) - I(1) = 3.15 - 4.43	Present
Senegal: ARDL(3, 2, 3, 3, 3, 3)	5	7.7477***	I(0) - I(1) = 3.41 – 4.68	Present
South Africa: ARDL(4, 4, 0, 3, 3)	4	11.4310***	I(0) - I(1) = 3.74 - 5.06	Present

Notes: $^{\#}k$ represents the number of independent variables included in the estimated equations. Asymptotic critical value bounds are obtained from Pesaran et al. (2001): Table CI(iii) Case III: Unrestricted intercept and no trend. I(0) and I(1) represent the lower and upper bounds respectively. Whenever the value of the F-statistic exceeds the upper bound (I(1)), we conclude that there is a long-run relationship among the variables. ***,**,* denote statistical significance at the 1% , 5% and 10% levels respectively.

4.3 Long-run and short-run relationships

Hence, we estimate our models based on the ARDL estimation and the chosen lag lengths. The long-run and short-run coefficient estimates are reported in Table 2 and Table 3 respectively. It can clearly be observed from the tables that the determinants of the real effective exchange rate vary accordingly based on the country investigated. A difference can also be noted in the sign, size and statistical significance of the estimated coefficients. This is due to the fact that these countries do not share the same characteristics. Indeed, they differ in terms of their location, their level of development, their economic environments, their extent of openness to international trade, and their policies adopted for exchange rate and capital controls. According to the estimation results presented in Table 2, a rise in the real GDP per capita, as suggested by the Balassa-Samuelson hypothesis, leads to the appreciation of the real effective exchange rate of all countries, with the exception of Botswana. Second, an improvement in terms of trade, government consumption and price level are also associated with the appreciation of the real effective exchange rate, except for Botswana, Ghana and Nigeria. However, an increase in trade openness, investment, net foreign assets,

official development assistance and money supply cause a depreciation in the real effective exchange rate except for Kenya, Ghana, Madagascar, Central African Republic and Cameroon. An in-depth analysis of the results shows that on average a 1 percent increase in terms of trade, real GDP per capita, government consumption and inflation cause the real effective exchange rate to increase by 0.40, 0.69, 0.94 and 0.05 percents respectively. On the other hand, it can be observed that on average a 1 percent increase in trade openness, investment, net foreign assets, official development assistance and money supply cause the real effective exchange rate to decrease by 0.35, 0.15, 0.79, 0.11 and 0.52 percents respectively. The signs of most of our estimated long-run coefficients corroborate with theories and existing studies conducted on Sub-Saharan African (SSA) countries and developing countries (see Aron et al., 1997; Mkenda, 2001; Drine and Rault, 2003; Iimi, 2006; Chudik and Mongardini, 2007; Carrera and Restout, 2008; López Villavicencio and Bara, 2008; Elbadawi et al., 2012) except for investment. As pointed out in the previous section, the effect of investment on exchange rate is unambiguous. Our findings reveal a positive relationship between investment and the real effective exchange rate. This could be explained by the fact that investment could have captured the real GDP per capita as highlighted by Chudik and Mongardini (2007) upon estimating the determinants of the exchange rate for a sample of developing countries. Moreover, it can be seen from Table 3 that the coefficient of the error-correction term is statistically significant and negative for all countries. It is also smaller than one. This not only validates the long-run relationship among the variables, but also reflects the convergence of the real effective exchange rate towards its long-run equilibrium since it measures the degree of adjustment of the actual real effective exchange rate with its equilibrium level. It can be observed from the table that the estimates of the speed of adjustment vary from -0.5023 to -0.9905. This disparity in the speed of adjustments across countries has been highlighted in previous empirical studies (see Mkenda, 2001; Elbadawi and Soto, 1994; Elbadawi and Soto, 1997). A closer look at the error correction terms reveals that on average, 74 percent of the adjustment in the real effective exchange rate takes place within a year for all countries investigated.

Table 2: Estimated Long-run Coefficients (dependent variable: $reer_t$)

	Regressors									
	tot_t	$open_t$	gdp_t	inv_t	gov_t	inf_t	nfa_t	oda_t	ms_t	R^2
Botswana: ARDL(1, 0, 0, 1, 0, 1, 1)										
Coefficient	-0.2619**	-0.1055	-0.0584*			-0.0737*	-0.1143***	-0.0430***		0.9315
t-ratio	-2.5591	-1.0242	-1.7911			-1.9490	-3.6306	-3.2435		
Cameroon: ARDL(1, 3, 0, 2, 3, 2)										
Coefficient	0.5934**	-0.3603*	0.8286***				-2.7982**		0.6476***	0.9746
t-ratio	2.2179	-2.1325	5.8250				-2.8333		4.5096	
Central African Republic: ARDL(1, 1, 1, 1, 1, 1)										
Coefficient	0.1545**	-0.4554**	1.6686***	-0.1478*				0.1903*		0.9567
t-ratio	2.4128	-2.0841	4.8196	-1.8222				1.9386		
Ghana: ARDL(3, 2, 3, 0, 0)										
Coefficient	1.2071***	-0.4666***	-1.8318***				1.0836*			0.9890
t-ratio	3.5226	-3.4501	-4.2684				1.8538			
Kenya: ARDL(1, 2, 1, 2, 0, 1, 2)										
Coefficient	0.1584	1.2841***	3.6001***		0.4851**			-0.4767***	-0.8192***	0.9620
t-ratio	0.4606	5.9855	8.5383		2.1486			-9.7090	-3.7330	
Madagascar: ARDL(2, 2, 2, 2, 1, 3, 1)										
Coefficient	0.1487	-0.7833***	1.1798**		1.0570***		0.6376***	-0.1020**		0.9930
t-ratio	0.5056	-5.7163	2.7109		6.0467		6.6379	-2.8031		
Nigeria: ARDL(1, 1, 0, 1, 2, 0, 1)										
Coefficient	1.5551***	-0.12674	-2.3818***		1.2869***		-2.6332**		-1.0122***	0.9506
t-ratio	4.5626	-0.5588	-4.4927		8.4804		-2.8238		-4.5292	

Senegal: ARDL(3, 2, 3, 3, 3, 3)										
Coefficient	0.3044***	-1.3937***	1.3398***			0.1831***	-0.9106***			0.9963
t-ratio	4.2505	-6.8836	5.5954			5.5954	-8.2924			
South Africa: ARDL(4, 4, 0, 3, 3)										
Coefficient	-0.2507	-0.74483*	1.8560***						-0.9122**	0.9769
t-ratio	-0.6624	-2.1621	4.6359						-2.5730	
Average Elasticity	0.4005	-0.3503	0.6890	-0.1478	0.9430	0.0547	-0.7892	-0.1079	-0.5240	

Notes: Models have been chosen based on the SIC; ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Table 3: Error-correction representation for the selected ARDL (dependent variable: $\Delta reer_t$)

	Regressors									
	Δtot_t	$\Delta open_t$	Δgdp_t	Δinf_t	Δnfa_t					ECM_{t-1}
Botswana: ARDL(1, 0, 0, 1, 0, 1, 1)										
Coefficient	-0.1482**	-0.1594**	-0.4463***	-0.0471**	-0.1986***					-0.8849***
t-ratio	-2.1643	-2.2820	-3.8684	-2.2831	-7.0236					-5.8855
	Δtot_{t-1}	Δtot_{t-2}	$\Delta open_t$	Δgdp_t	Δgdp_{t-1}	Δnfa_{t-1}	Δnfa_{t-2}	Δms_{t-1}		ECM_{t-1}
Cameroon: ARDL(1, 3, 0, 2, 3, 2)										
Coefficient	-0.4406***	-0.1259*	-0.3335***	-1.1277***	1.3851***	2.3098***	1.9380***	0.2001*		-0.9905***
t-ratio	-4.9730	-1.7672	-3.3467	-3.004	3.9001	4.2077	3.2828	1.8186		-6.9263
	Δtot_t	$\Delta open_t$								ECM_{t-1}
Central African Republic: ARDL(1, 1, 1, 1, 1, 1)										
Coefficient	0.4332***	-0.5547***								-0.7631***
t-ratio	3.5431	-4.4357								-5.7540
	$\Delta reer_{t-2}$	Δtot_t	Δtot_{t-1}	$\Delta open_t$	$\Delta open_{t-2}$					ECM_{t-1}
Ghana: ARDL(3, 2, 3, 0, 0)										
Coefficient	0.3094***	0.5455***	-0.5495***	-0.3710***	0.2963**					-0.5023***
t-ratio	3.0763	3.6711	-3.6725	-3.5514	2.2974					-5.7994
	Δtot_t	Δtot_{t-1}	$\Delta open_t$	Δgdp_t	Δgdp_{t-1}	Δgov_t	Δoda_t	Δms_t	Δms_{t-1}	ECM_{t-1}

Kenya: ARDL(1, 2, 1, 2, 0, 1, 2)										
Coefficient	0.2975**	0.5000***	0.4482***	0.9507**	-1.9233***	0.5148***	-0.1564***	-0.4615***	-0.2763**	-0.8107***
t-ratio	2.6346	4.6027	3.7798	2.2693	-3.7118	3.7034	-3.7673	-3.7667	-2.3076	-7.7769
	$\Delta reer_{t-1}$	Δtot_{t-1}	$\Delta open_t$	$\Delta open_{t-1}$	Δgdp_{t-1}	Δgov_t	Δnfa_{t-1}	Δnfa_{t-2}	Δoda_t	ECM_{t-1}
Madagascar: ARDL(2, 2, 2, 2, 1, 3, 1)										
Coefficient	0.5082***	-0.5858***	-0.3324***	0.5831***	-1.3259***	0.5540***	-0.1099**	-0.1598***	-0.1423***	-0.7112***
t-ratio	5.4995	-6.4912	-5.5292	6.6613	-4.8664	11.8739	-2.7339	3.5378	-7.0563	-8.5039
	Δtot_t	Δgov_t	Δgov_{t-1}	Δnfa_t						ECM_{t-1}
Nigeria: ARDL(1, 1, 0, 1, 2, 0, 1)										
Coefficient	0.5288***	0.6139***	0.2199**	-2.3306***						-0.7798***
t-ratio	3.8212	5.3218	2.2465	-3.4847						-8.8794
	$\Delta reer_{t-1}$	$\Delta reer_{t-2}$	Δtot_t	Δtot_{t-1}	$\Delta open_{t-1}$	$\Delta open_{t-2}$	Δgdp_{t-2}	Δinf_{t-1}	Δnfa_{t-1}	ECM_{t-1}
Senegal: ARDL(3, 2, 3, 3, 3, 3)										
Coefficient	1.2562***	1.5589***	1.4957***	0.2897***	0.6090***	0.6654***	0.9869**	-2.0307***	-0.2100***	-0.5302**
t-ratio	5.0623	5.4183	6.9354	2.4985	4.4832	4.5274	2.8412	-5.3523	-6.4872	-2.85
	$\Delta reer_{t-1}$	$\Delta reer_{t-3}$	Δtot_{t-1}	Δtot_{t-3}	$\Delta open_t$	Δgdp_{t-1}	Δgdp_{t-2}	Δms_{t-2}		ECM_{t-1}
South Africa: ARDL(4, 4, 0, 3, 3)										
Coefficient	0.5037***	0.3262***	2.4048***	0.9837***	-0.6011***	-1.2717**	-1.1057**	0.8776***		-0.7519***
t-ratio	6.9078	4.2314	7.4752	3.8666	-5.5823	-2.6798	-2.2352	5.1344		-8.7259
Average										-0.7471

Notes: Models have been chosen based on the SIC; Only significant results have been reported; ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

5. Conclusion

This study has examined the long-run and short-run determinants of the real effective exchange rate in a sample of nine SSA countries using annual data from 1980 to 2013 (34 years). In particular, the relationship between the real effective exchange rate and its potential determinants - terms of trade, trade openness, real GDP per capita, investment, money supply, government consumption, net foreign assets, official development assistance and price level - have been explored. After some preliminary tests and analysis on our data set, the ARDL model has been adopted for further investigation. The results show that for both the long-run and short-run, the determinants of the real effective exchange rate vary accordingly based on the country investigated. A difference has also be noted in the sign, size and statistical significance of the estimated coefficients. This is due to the fact that these countries do not share the same characteristics. Indeed, they differ in terms of their location, their level of development, their economic environments, their extent of openness to international trade, and their policies adopted for exchange rate and capital controls. The findings from this study will thus be useful whenever important policy measures on capital and exchange rate controls need to be applied to maintain the currency of these countries in equilibrium.

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