

AN ECONOMETRIC ASSESSMENT OF THE REAL EFFECTIVE EXCHANGE RATE VOLATILITY IN KENYA

ABSTRACT

A country's real effective exchange rate (REER) is an important determinant of the growth of cross-border trading and it serves as a measure of its international competitiveness. The REER is an active source of discussions in Kenya where questions have arisen revolving around persistent exchange rate shocks and possible interventions. Kenya's vulnerability to the external shocks has increased and the real effective exchange rate has experienced episodes of appreciations. There is no known study that has specifically focused on the Kenyan's real effective exchange rate (REER). This study carried out an assessment of the real effective exchange rate (REER) volatility in Kenya. The study was guided by the Dornbusch over-shooting model and adopted correlation Research Design. It relied on secondary data for the period 1972 – 2015. Quarterly data for the study was collected from Kenya National Bureau of Statistics, Central Bank of Kenya, International Monetary Fund Database and the World Bank Database. To overcome the methodological deficiencies of using the measures of unconditional volatility, this study focused on the conditional volatility employing the GARCH technique that is a superior measure of uncertainty. The Augmented Dickey-Fuller and Phillip-Perron approaches were used to test for the presence of unit roots. Findings of this study will add value to the Dornbusch over-shooting model, production flexibility and risk aversion theories and partial and general equilibrium theories and will further help in the formulation of fiscal and monetary policies to address macro-economic shocks associated with REER shocks in the Kenyan economy.

Key Words: Real Effective Exchange Rate, Conditional Volatility, Macro-Economic Shocks.

1.0 Introduction

An exchange rate is a rate at which one currency may be converted into another currency. Among other things, the exchange rate determines how much the residents of a country pay for imported goods and services, and how much they receive as payments for exported goods and services. The exchange rate can be expressed as nominal exchange rate (NER) when inflation effects are embodied in the rate and as the real exchange rate (RER when inflation influences have been excluded.

The NER can, in turn, be expressed in bilateral or multilateral terms. If expressed in bilateral terms, it is referred to as the nominal exchange rate (NER) and refers to the exchange rate of one currency regarding another (Copeland, 1989). On the other hand, a multilateral nominal effective exchange rate (NEER) is the rate of one currency against a weighted composite basket of the country's trading partner currencies. When NEER is adjusted for inflation, it becomes the real effective exchange rate

(REER) which was the focus of this study. Kenya trades with more than one country, hence, the need to focus on the composite basket of trading partner currencies.

The exchange rate is measured as a unit of domestic currency vis-à-vis a unit of the US Dollar. This is measured in real terms as the real effective exchange rate (REER). This is the most appropriate measure of the real exchange rate for a study of this nature given its ability to capture and measure the international competitiveness of countries. Moreover, it has been weighted by the level of trade and investment between each country and the rest of the world (Kiyota and Urata, 2004). This has the advantage of eliminating the bias of the sample towards actual investors when bilateral exchange rates are used and account as much as possible for potential investors in the sense that investors, actual and potential, are more likely to come from countries that are already in a trading relationship with the country in question.

Real Effective Exchange Rate (REER) volatility refers to short term fluctuations of the REER about their longer term trends (Frenkel and Goldstein, 1986). It also entails short-term (monthly, weekly, or even hourly) fluctuations in the exchange rates as measured by their absolute percentage changes during a particular period (Williamson *et al.*, 1985). Increased, REER volatility may lead to higher prices of internationally traded goods by causing traders to add a risk premium to cover unanticipated exchange rate fluctuations (McKinnon & Ohno, 1997; McKinnon, 1963).

The exchange rate is used as a parameter for determining international competitiveness, and it is regarded as an indicator of the competitiveness of the currency of any country and that an inverse relationship between this competitiveness exists. To this end, the lower the value of this indicator in any country, the higher the competitiveness of the currency of that country will be. In other words, the real exchange rate plays a crucial role in guiding the broad allocation of production in the domestic economy and spending between foreign and domestic goods. The real exchange rate's level, about an equilibrium real exchange rate level, and its stability have been shown to importantly influence export growth, consumption, resource allocation, employment and private investments (Wright, Aron, McLaughlin-Volpe and Ropp, 1997). Because of this important role the real exchange rate plays in an economy, there is need to investigate the influence of REER volatility on

macroeconomic performance of an economy. The appropriate real effective exchange rate is one that does not wonder too far from its equilibrium value.

Advocates of fixed exchange rate argue that the exchange rate stability enhances cross-border trade and provides an attractive environment for the flow of international capital like foreign direct investment (FDI), and eventually stimulates economic growth. In their view, volatile and unpredictable fluctuations of the exchange rate may lead to many harmful macroeconomic consequences such as volatility of prices and output, deterioration of total exports as well as worsening the external competitiveness (Gylfason, 2000; Rose, 2000; Frankel & Rose, 2002; and De Grauwe & Schnabl, 2004). On the other hand, proponents of floating exchange rate regime believe that exchange rate flexibility helps automatic balance of payments adjustments in response to external shocks and positively influence the trade volume and economic growth (Friedman, 1953 ;Aseidu, 2001; and Aseidu, 2003).

Like other developing countries that face the challenge of improving the balance of payments and stimulating economic growth, Kenya has adopted some different exchange rate regimes over the last five decades. From a fixed exchange rate regime up to 1982 to crawling peg during the period 1983 to 1993 before a floating exchange rate regime was adopted in 1993. Following the liberalization of the foreign exchange market, Kenya attained monetary independence to control inflationary pressures but lost the nominal anchor to tie down domestic prices, and thus globalization effects are transmitted directly into the country through exchange rate volatility (Kiptui & Kipyegon, 2008). External shocks require appropriate fiscal and monetary policies to prevent the emergence of unsustainable current account deficits, growing foreign debt burdens and steady losses of international competitiveness while at the same time keeping the domestic rate of inflation at low levels, conducting a strict monetary policy stance and maintaining positive real interest rates. This has been difficult in practice.

Measuring exchange rate volatility is one of the controversial issues in the recent economic literature. Several measures of volatility have been employed in the literature, including standard deviations and Autoregressive Conditional Heteroscedasticity (ARCH) techniques. However, methods based on standard deviation suffer from many shortcomings. First, the standard deviation measures of exchange rate volatility ignore relevant information on the random process that

generates the exchange rate (Engle, 1982). Second, this method is arbitrary in choosing the order of the moving average and is noted for underestimating the effects of volatility on decisions (Pagan & Ullah, 1988). Furthermore, standard deviation measure of volatility is characterized by skewed distribution. Exchange rates are typified by volatility clustering, implying that future exchange rate changes are not independent of the past and current changes. To this extend, the applicability of the findings of the various studies based on standard deviation may be in doubt. To correct for this apparent deficiencies, the ARCH was introduced by (Engle, 1982) and later modified by (Bollerslev, 1986) as the GARCH. Ever since, different variants of the ARCH and GARCH models have emerged. One of the asserted superiority of the ARCH and its variants over the standard deviation measures is their ability to distinguish between predictable and unpredictable elements in the real exchange rate formation process, and are, therefore not prone to overstating volatility ((Arize, Osang, and Slottje, 2000), This study employed the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model to measure the real effective exchange rate (REER) volatility.

Throughout the economic adjustment agenda, exchange rate and trade reform occupy a core position. The real exchange rate, by its impact on international competitiveness of an economy, assumes an overriding importance among the cohort of policy variables. The real exchange rate is an active source of discussions in Kenya where questions have arisen both in the policy arena as well as within the public domain revolving around the possible reasons for persistent appreciation of the shilling real exchange rate against key currencies. Also, Kenya's economy is now experiencing a sharp decrease in the foreign exchange reserves. Kenya adopted a unified and flexible exchange rate in the early 1990s, as part of a market-based reform program designed to improve the investment environment and stir up economic growth (Ndung'u, 2008). Since then, the exchange rate has witnessed continuous shocks and interventions. These changes in the exchange rate have been accompanied by considerable fluctuations in the Kenya's economic growth. There is, however, no reliable information yet on whether real effective exchange rate has actually been. This study tried to fill this gap.

Balance of payments deficits have been a common phenomenon in the Kenyan economy from the 1960s. The government has over the years enacted various policy measures aimed at remedying the

situation; however the balance of payments situation does not seem to have improved despite this policy measures (Mwega & Ngugi, 2005.) . The deficit in the current account widened from a deficit of Ksh. 76.4 billion in the first quarter of 2011 to a deficit of 81.1 billion in the first quarter of 2012. The deterioration in the current account was mainly as a result of 20.8 per cent widening of the merchandise account deficit.

Kenya's overall balance of payments positions declined by US\$ 220.7 million from a surplus of US\$ 360million in May 2011 to a surplus of US\$ 139 million in May 2012 (Stratlink, 2012). The deterioration was largely due to narrowing of the current account. The current account deficit nearly doubled to 13.1% of GDP. Imports grew by almost 20%, while exports increased by 10%, thus representing a net export of -10%. Import growth was mainly driven by oil imports, which accounted for 27.6% of the total import bill in 2011, jumping from US\$ 2.7 billion (8.9% of GDP) in 2010, to USD 4.1 billion (11.6% of GDP) in 2011 (Stratlink, 2012).

Uncertainty stemming from a previous balance of payments position continues to suppress economic growth prospects. The country has a gaping current account deficit and with only \$3.7 billion in foreign exchange reserves – enough to cover a mere 3.44 months of imports – leaving the balance of payments in a shaky position (Stratlink, 2012). The latest Central Bank of Kenya (CBK) weekly bulletin shows that the usable official foreign exchange reserves held by the bank marginally increased from \$ 3.711 billion, which is equivalent to 3.44 months of imports in the week ending December 2012. CBK is required to maintain foreign exchange reserves equivalent to four months of import cover. For low to medium income oil-importing countries such as Kenya, the current account deficit should be within five to eight per cent band that is considered sustainable.

Despite rapid economic growth experienced between 1963 and 1970, the current account balance of payments remained in deficit except in 1963, 1964, 1965, 1977, 1993, 2003, 2009, and 2010 when it recovered a surplus of US\$ 10.1m, US\$ 50.6m, US\$ 0.5m, US\$ 25.9m, US\$ 124.5m, US\$ 132.4m, US\$ 9908.3m, and US\$ 11404.95m respectively. The adjustments in balance of payments in Kenya appears to be complicated because the receipts and expenditures are mostly financial and seldom in real assets.

Empirical studies on the Kenyan macro economy explaining the impact of shocks to real effective exchange rate movements on some selected macroeconomic indicators are scarce (Kiptui & Kipyegon, 2008). Pollin & Heintz (2007) called for a reassessment of monetary policy with a view to achieving a more depreciated shilling. The few studies that have been undertaken on the Kenyan economy have mainly concentrated on explaining the determinants of exchange rate behavior but not an empirical assessment of the relationship between REER volatility and macroeconomic performance. For instance, Were, *et al.* (2002) analyzed the factors that have influenced the exchange rate market since it was liberalized in 1993. A related study by Ndung'u (1997) assessed whether the exchange rates in Kenya were affected by monetary policy; and whether these effects were permanent or transitory. The study by Kiptoo (2007) focused on the real exchange rate volatility, and misalignment, and its impact on Kenya's international trade and investment. Sifunjo (2011) focused on chaos and non-linear dynamic approaches to predicting exchange rates in Kenya. Even then, these studies including (Ndung'u (2000); Ndung'u (2001); Kiptoo (2007); and Sifunjo (2011) did not focus on ascertaining the nature of real effective exchange rate in Kenya

A number of researchers have argued that real exchange rates are crucial not only for attaining sustained general economic performance and international competitiveness, but have a strong impact on resource allocation amongst different sectors of the economy, foreign trade flows and balance of payments, employment, structure of production and consumption and external debt crisis ((Edwards, 1988; Edwards & Savastano, 1999).

Recently, however, volatility increased posing challenges for macroeconomic management in Kenya (Kiptui & Kipyegon, 2008). Kenya, like other developing countries, has experienced a combination of exogenous shocks such as worsening terms of trade mainly on account of fluctuations in international commodity prices, oil price shocks and volatility in capital flows, which have created macroeconomic management policy challenges. Therefore, understanding the nature of exchange rate volatility would help in guiding appropriate exchange rate policies that foster exports' competitiveness, attract foreign financial sources such as FDI, improving the balance of payments and stimulating economic growth.

1.8 Theoretical Framework

Traditionally two views of exchange rates have been predominant. One regards the exchange rate as the relative price of two monies; in the other, the exchange rate is viewed as the relative price of domestic and foreign goods. These real and monetary aspects of the exchange rate determination are the most extensively modeled. A third view takes into account portfolio considerations and regards the exchange rate as the relative price of nominal assets. It has been only recently that some interest in the portfolio approach has emerged in the form of exchange rate theory oriented to the current account (Dornbusch, 1980).

An alternative to the simple monetary model is a disequilibrium macroeconomic model that considers the differential speeds of adjustment in asset and goods markets. This leads us to the sticky-price monetary approach to the exchange rate. The most common Sticky-Price Monetary Model (SPMM) is the Dornbusch (1976) over- shooting model, which is basically an extension of the Mundell-Fleming model (Obstfeld and Rogoff, 1996; Donald, 1988). Hence this model is also known as the Mundell-Fleming-Dornbusch model. In it, the nominal output prices are assumed to be sticky - they adjust slowly over time.

On the other hand, asset markets clear continuously in response to new information or changes in expectations (Marrinan, 1989). The model thus adopts the principle of the Uncovered Interest Parity (UIP), but PPP need not hold. A small country with an open economy is faced with a foreign interest, which is assumed to be constant. With open capital markets and perfect foresight, UIP is assumed to hold continuously.

Because of the sluggish adjustment of the national price level, a purely nominal shock or disturbance can cause short-run deviations from PPP and overshooting of the nominal exchange rate (McDonald, 1988). Hence the model is popularly known for its demonstration of overshooting (and undershooting) behavior in exchange rates (Dornbusch, 1976 ;Marrinan, 1989; Obstfeld and Rogoff, 1996).

The consequences for the short run behavior of the exchange rate, given imperfect price flexibility, are to generate ‘over – shooting’. That is, given an initial disturbance, the exchange rate first moves

beyond its long run equilibrium level, and then in the longer run moves back. This provides an explanation of an empirical phenomenon which attracted much attention in the late 1970s and early 1980s. In particular, it was the common experience of Switzerland, West Germany and the UK that the adoption of heavily publicized strict monetary targets was followed by a substantial appreciation in the real exchange rate of the respective currencies (J – curve phenomenon).

2.2 Theoretical Review

2.2.1 Measuring Real Effective Exchange Rate Volatility

The Dornbusch (1988) Model with its long run properties are generally in accord with the Monetary Model. In the short run, however, prices are sticky and the impact of a change in the domestic money supply is to change the real exchange rate, with at least the possibility of real consequences for the domestic economy, in the spirit of the Mundel- Fleming Model. In the sense, the Dornbusch Model is an example of a halfway house which is somewhat familiar in modern macroeconomics, where monetary policy has real (Keynesian) effects in the short run and is neutral (in a neoclassical manner) in the long run.

First the long run equilibrium properties of the model are identical to those of the monetary approach (Asset market equilibrium lies at the center of the model) where the asset in question is money and, where the demand for money function is stable and the supply of money is determined by the authorities. The economic interpretation of this is that as the exchange rate rises, aggregate demand rises as net exports respond to increased competitiveness. This is offset by a rising price level which reduces aggregate demand via two mechanisms. First, the increased price level reduces competitiveness and therefore net exports. Secondly, the increasing of the price level also has the effect of reducing the real money stock, therefore increasing the domestic interest rate (the ‘Keynes effect’) which also reduces aggregate demand.

The Dornbusch model is interesting for its properties of dynamic adjustment, once the crucial assumption is made that asset markets adjust more quickly than do goods markets and that in the short run, the price level is sticky, while goods prices are fixed in the short run and only adjust gradually in the long run. Thus, an increase in the money stock increases real income in the short

run, both because of the fall in the interest rate and because of the (overshooting) the rise in the real exchange rate. In this guise, it is tempting to see the Dornbusch model as reconciliation between Mundel – Fleming as a short run exercise, and the monetary approach as the long run equilibrium to which it tends.

Despite its popularity, the Dornbusch model has methodological limitations when examined from micro-foundation perspective. First, the model lacks explicit choice-theoretical foundations, particularly concerning micro-foundations of aggregate supply (Obstfeld & Rogoff, 1996). Its specification of the price determination is ad hoc. The model also is ill-equipped to capture current account dynamics or the effects of government spending, since it does not account for private or government inter-temporal budget constraints (Obstfeld & Rogoff, 1996). In addition, it does not explicitly model the implicit bond market. Nevertheless, the model has played a dominant role in the literature on exchange rate dynamics and remains one of the basic building blocks of open economy macro-models.

3.0 Methodology

The study measured the REER volatility using the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) developed by (Bollerslev, 1986). The GARCH method can discriminate between predictable and unpredictable elements in the exchange rate formation process, and therefore, they serve as accurate measures of volatility (Darrat and Hakim, 2000).

To overcome the methodological deficiencies of standard deviation methods, the study used the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) developed by (Bollerslev, 1986). The advantage of the GARCH method over the standard deviation measures is their ability to discriminate between predictable and unpredictable elements in the exchange rate formation process, and therefore, they serve as accurate measures of volatility (Arize *et al.*, 2000 and Darrat & Hakim, 2000).

The proposed study investigated the relationship between exchange rate volatility and macroeconomic performance in Kenya, focusing on some selected macroeconomic indicators, namely; economic growth, foreign direct investment, and current account balances during the period

1972q1 – 2015q4. The study measured the real effective exchange rate (REER) volatility using the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model. The Vector Error Correction Model was used to establish the impact of exchange rate volatility on those selected macroeconomic indicators.

Therefore, the conditional variance of GARCH model could be specified as follows:

$$\ln REER_t = \alpha_0 + \alpha_1 \ln REER_{t-1} + e_t, \text{ where } e_t \sim (0, h_t) \dots\dots\dots (3.10)$$

$$h_t = \alpha + \beta e_{t-1}^2 + \gamma h_{t-1} + \mu_t \dots\dots\dots (3.11)$$

This equation means that the conditional variance is a function of three terms: the mean, ; information about volatility from the previous period, measured as the lag of the squared residual from the mean equation e_{t-1}^2 (the ARCH term), and the variance of previous period's forecast error, h_t (the GARCH term). Accordingly, we will estimate GARCH (1,1) conditional variance on quarterly real effective exchange rate (REER) over the period 1972-2015.

3.5.1 Data Type and Sources

The quarterly data set covering the period 1972- 2015 was selected because since 1972 the exchange rate has seen many policy interventions in Kenya. Also, by the end of the 1970s, the country had started to suffer from unfavourable economic situations. Moreover, this period ensures the availability of data on the variables under investigation.

The data on REER included trade volume with major trading partners, real bilateral exchange rate, foreign price index calculated as the weighted CPI index and the domestic CPI.

The quarterly data series was sourced from various issues of the Central Bank of Kenya (CBK), Kenya National Bureau of Statistics, International Monetary Fund (IMF), UNCTAD and World Bank's world development indicators.

3.2 Measurement of Variables

313 **An Exchange Rate:** Is the rate at which Kenyan currency may be converted into another currency.
 314 Among other things, the exchange rate determines how much the residents of Kenya pay for
 315 imported goods and services, and how much they receive as payments for exported goods and
 316 services.

317 **Nominal Exchange Rate:** refers to the exchange rate of the Kenyan currency regarding another
 318 expressed in bilateral terms.

319 **Nominal Effective Exchange Rate** is the rate of the Kenyan currency against a weighted composite
 320 basket of the Kenya's trading partner currencies.

321 **Real Exchange Rate:** is expressed as the Nominal Exchange Rate adjusted for inflation.

322 **Real Exchange Rate Volatility:** refers to short term fluctuations of the RER about their longer term
 323 trends. It also entails short-term (monthly, weekly, or even hourly) fluctuations in the exchange
 324 rates as measured by their absolute percentage changes during a particular period.

325 **Real Effective Exchange Rate** is the rate of the Kenyan currency against a weighted composite
 326 basket of the Kenya's trading partner currencies adjusted for inflation.

327 3.6.2 Integration properties (Unit root test)

328 The Classical Econometric Theory assumes that observed data are usually stationary in nature,
 329 whereby means and variances are constant overtime. However, the estimates of time series
 330 econometric models and historical records of economic forecasting invalidate such assumptions. To
 331 avoid spurious regression results, stationarity is important for empirical modeling.

332 A time series variable has the property of stationarity when it possesses a finite mean, variance and
 333 autocovariance function that are all independent of time. Analogously, a non-stationary series
 334 possesses a time dependent mean or autocovariance function. A stochastic time series is said to be
 335 integrated of order d if the series requires differencing d times in order to achieve stationarity (Engle
 336 and Granger 1987). Note that by stationarity we mean covariance or weak stationarity, meaning the
 337 property that a time series variable possesses a finite mean, variance, and autocovariance function
 338 that are all independent of time (Nyongesa D., 2013).

339 As is common in time series analysis, before estimating our regression models, all series require to
 340 be tested for the unit root to avoid the spurious regression. Therefore, the analysis started with
 341 identifying the order of integration of the variables, using Augmented Dickey-Fuller (ADF), Philips-

Perron (PP) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests for a unit root. Since the unit root tests are sensitive to the lag length, the study uses the Akaike Information Criterion (AIC) to select the optimal lag length. The study utilized the quarterly time series data covering the period 1972-2015.

3.6.2.4 Cointegration Analysis

After establishing the order of integration, the next step was to establish whether the non-stationary variables are cointegrated. According to Engle and Granger (1987), individual time series could be non-stationary, but their linear combinations can be stationary if the variables are integrated of the same order. This is because equilibrium forces tend to keep such series together in the long-run. As such, the variables are said to be cointegrated and error-correction terms exist to account for the short – term deviations from the long-run equilibrium relationship implied by the cointegration. Furthermore, the differencing of non-stationary variables to achieve stationarity leads to loss of some long-run properties. To test for cointegration among the non-stationary series can be carried out using either Engel – Granger two – step procedure or Johansen procedure. A more superior multivariate technique developed by (Johansen, 1988) and applied in (Johansen and Juselius, 1990) was used.

Engle and Granger (1987) advocate ADF tests of the following kind:

$$\Delta \varepsilon_t = \mu \varepsilon_{t-1} + \sum \mu_i \Delta \varepsilon_{t-1} + \mu + \delta_t + s_t \dots\dots\dots (3.31)$$

Where $s_t \sim \text{NID}(0, \sigma^2)$

The residual based on ADF test for cointegration assumes that all the variables in the Ordinary Least Square (OLS) equation are all integrated of order one (1) such that the cointegration test gears to establish whether the error term is integrated of order one $\varepsilon_t \sim I(1)$ against the alternative that is integrated of order zero $\varepsilon_t \sim I(0)$. If some of the variables are in fact integrated of order two $I(2)$, then cointegration is still possible if the $I(2)$ series cointegrates down to $I(1)$ variable to cointegrate potentially with other $I(1)$ variables.

3.6.2.5 Error Correction Model (ECM)

If the variables are cointegrated, estimating the equation in first difference results in the loss of valuable information on the long run relationship between the levels of the variables. Therefore, first

differencing is an unsatisfactory method of dealing with the spurious problem. The appropriate method is to use Error Correction Model (ECM) that results in equations with first differenced and hence stationary dependent variables but avoid the problem of failing to make use of any long run information in the data. The result of cointegration test enables us to formulate an ECM. ECM relates short run changes in the dependent variable Y_t to short run changes in the explanatory variables (the impact effect), but also the long run effect through a feedback mechanism.

3.6.3.1 Measuring Real Effective Exchange Rate

The real exchange rate (RER) was obtained by adjusting nominal exchange rate (NER) with inflation differential between domestic economy, and foreign trading partner's economies. The derivation of the RER, therefore, requires that the data of the NER, domestic inflation and foreign inflation be obtained. Since the Kenyan shilling appreciated against some currencies and depreciated against others during the study period, the nominal effective exchange rate (NEER) is constructed. The NEER was delivered by weighting the bilateral shilling exchange rate against its trading partners currencies using the value of Kenya 'trade (imports plus exports) with its respective trading partners. The data required to derive the NEER is the Kenya's bilateral exchange rates with respective trading partners. Since some of the data on bilateral exchange rates are originally expressed regarding United States (US) dollars, cross rates was obtained, so as to have all bilateral exchange rates expressed regarding Kenya shilling per foreign currency. The calculation of NEER was achieved through the arithmetic mean approach that involves summing up the trade weighted bilateral exchange rates as shown in Equation 3.1 below.

$$NEER = \sum_{it}^n ER_{it} * W_{it} \dots \dots \dots (3.22)$$

Where ER_{it} is Kenya's bilateral exchange rate index with country i at time t while W_{it} is the bilateral trade weight for Kenya's i^{th} trading partner at time t . Each bilateral exchange rate index (ER_{it}) in Equation 3.22 is computed as follows

$$ER_{it} = \left[\frac{NER_c}{NER_{t=0}} \right] * 100 \dots \dots \dots (3.23)$$

Where, the NER_c is an index of Kenya shilling exchange rate per unit of trading partners currency in the base period (2007) while $NER_{t=0}$ is the index of Kenyan shilling exchange rate per unit of trading partner currency in the current period/ year. The choice of 2007 as the base year is rationalized regarding relative stability of the economy and low volatility in the domestic, foreign exchange

market during the year. Kenya's Gross Domestic Product (GDP) growth rate during this period was 7.1%, the highest rate ever achieved during the 1972-2015-study period. The year 2007 also enjoyed macroeconomic stability, with an inflation rate that were not only low but also stable while the current account balance, as well as fiscal deficits, were considered to have been at sustainable levels. Each monthly bilateral trade weight in equation (3.22) was computed as a ratio of total trade (exports plus imports for each trading partner to the ratio of total trade (pus export imports) for all Kenya's trading partners. The formula to be used in deriving the trade weights is:

$$w_{it} = \left[\frac{\sum (X_{it} + m_{it})}{\sum (X_t + m_t)} \right] \dots \dots \dots (3.24)$$

Where X_{it} is the total value of Kenyan's exports to i^{th} trading partner at time t . M_t is the total value of imports from Kenya's i^{th} trading partner also in time t . X_t are Kenya's total exports to all trading partners at time t , and M_t are total imports to all trading partners at time t . In this study $i=1,2,\dots,n$. Where n is the total number of Kenyan's trading partners which in this study will be 140. The NEER is obtained by combining equation 3.23 and equation 3.24 using the following formula.

$$\dots \dots \dots (3.25)$$

Where ER_t is the bilateral exchange rate (equation 3.23) and W_t is the bilateral trade weight, n is the total number of countries which is 50. Based on (equation 3.25) a decline in NEER represents an appreciation while an increase represents a depreciation of the NEER. This is because in the calculation of the NEER index, the base year (2007) exchange rate is taken as the denominator while the current exchange rate is taken as the numerator.

In order to obtain the real effective exchange rate (REER), the NEER was adjusted by the relative price indices of Kenya and the weighted average price indices of Kenya's trading partners. In an equation form, this is expressed as:

$$REER_t = NEER_t \left[\frac{P_{wt}}{P_{dt}} \right] \dots \dots \dots (3.26)$$

Where P_{dt} is the price level in Kenya proxied by consumer price index (CPI) at time t and PW_t is the weighted average price level of Kenya's trading partner countries proxied by weighting CPI at time t

.The price level of Kenya's trading partner countries is obtained by adding all the trade weighted price levels proxied by CPI of Kenya trading partners.

This is shown in an equation form as follows:

$$P_{wt} = \sum_{it}^n P_{it} * W_t \dots \dots \dots (3.27)$$

Where P_{it} is the price level of Kenya's i^{th} trading partner country's proxied by CPI at time t . W_{it} is the trade weight of Kenya's i^{th} trading partner country at time t . These weights are the same as those in the derivation of REER.

3.6.3.2 Generalized Autoregressive Conditional Heteroscedasticity (GARCH)

Since its "discovery" by (Engle, 1982), ARCH modeling has become a growth industry, with all kinds of variations on the original model. One that has become popular is the generalized autoregressive (GARCH) model, originally modified by (Bollerslev, 1986) as the GARCH. The simplest GARCH model is the GARCH (1, 1) model, which can be written as:

$$\delta_t^2 = \alpha_0 + \alpha_1 \mu_{t-1}^2 + \mu_2 \sigma_{t-1}^2 \dots \dots \dots (3.28)$$

Which says that the conditional variance of μ at time t depends not only on the squared error term in the previous time period as in ARCH (1) but also on its conditional variance in the previous time period? This model can be generalized to a GARCH (p, q) model in which there are p lagged terms of the squared error term and q terms of the lagged conditional variances. We will not pursue the technical details of these models, as they are involved, except to point out that a GARCH (1,1) model is equivalent to an ARCH (2) model and a GARCH (p, q) model is equivalent to an ARCH ($p + q$) model.

Financial time series, such as stock prices, exchange rates, inflation rates, etc. often exhibit the phenomenon of volatility clustering, that is, periods in which their prices show wide swings for an extended time period followed by periods in which there is relative calm. As (Philip Franses, 2002) notes:

Since such (Financial time series) data reflect the result of trading among buyers and sellers at, for example, stock markets, various sources of news and other exogenous economic events may have an impact on the time series pattern of asset prices. Given that news can lead to various interpretations, and also given that specific economic events like an oil crisis

can last for some time, we often observe that large positive and large negative observations in financial time series tend to appear in clusters.

Knowledge of volatility is of crucial importance in many areas. For example, considerable macro econometric work has been done in studying the variability of inflation over time. For some decision makers, inflation in itself may not be bad, but its variability is bad because it makes financial planning difficult.

The same is true of importers, exporters, and traders in foreign markets for variability in the exchange rates mean huge losses or profits. Investors in the stock market are obviously interested in the volatility of stock prices, for high volatility could mean huge losses or gains and hence greater uncertainty. In volatile markets it is difficult for companies to raise capital in the capital markets.

4.0 Empirical Results

4.1 Descriptive Statistics

The first step of the analysis was to compute the descriptive statistics reported in table 4.1 below. The real effective exchange rate recorded a maximum of -0.2827, a minimum of -4.6584 and an average of -2.0572.

Table 4.1 also presents the results of normality test. REER was also normally distributed with 857.5843 Jarque-Bera statistic and p – value $0.0028 < 0.05$ indicating that it follows normally distributed.

Table 4. 1: Descriptive Statistics

Variable	Mean	Std.Dev	Minimum	Maximum	Skewness	Kurtosis	Jarque-Bera	Probability
REER	-2.0572	1.1350	-4.6584	-0.2827	0.0004	0.2995	857.5843	0.0028

Note: Sample, 1972q1 – 2015q4; N = 176

Source: Author's Research, 2017

The time series plot of REER showed that it was trending. This was in line with economic theory (Lutkepohl 2005).

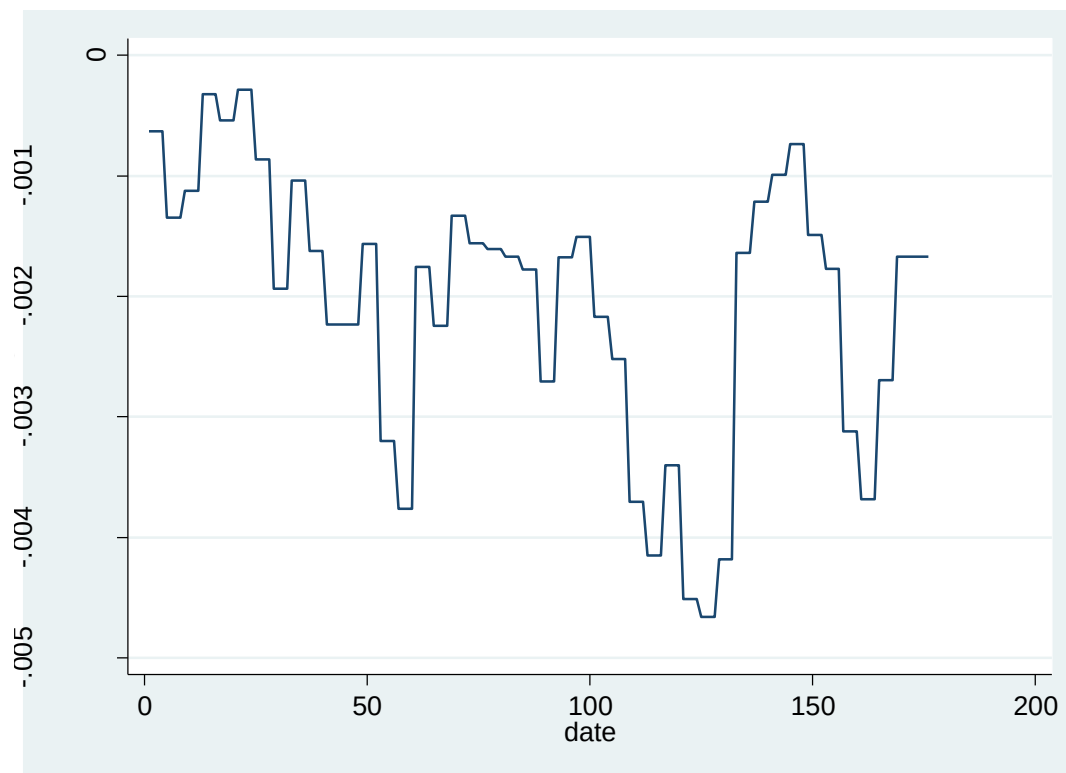


Figure 4.1: Time series plot for Real Effective Exchange Rate

4.5 Unit Root Tests without Structural Breaks

4.5.1 Augmented Dickey-Fuller Unit Root Test

Results of Augmented Dickey-Fuller presented in table 4.3 showed that real effective exchange rate was integrated of order one ($I(1)$).

Table 4. 2: Results of Augmented-Dickey-Fuller Unit Root Test

Variable	Intercept		Intercept and Trend		None		Remark
	T – Stat	Prob	T – Stat	Prob	T – Stat	Prob	
Level							
REER	-2.6278	0.0893	-2.6230	0.2707	-1.0867	0.2504	
First Difference							
REER	-13.1175	0.0000	-13.1042	0.0000	-13.1530	0.0000	$I(1)$

Source: Author's Survey 2017

When variables were first differenced results showed that they became stationary. Therefore it was concluded that the study variables were integrated of order one denoted by $I(1)$ as per Augmented Dickey-Fuller test.

4.5.2 Results of Phillips-Perron Unit Root Test

Results of Phillips-Perron are presented in table 4.4 showed that unit root was present in real exchange rate volatility. Mackinnon p – value was $0.0720 > 0.05$. The critical values for Augmented Dickey-Fuller test were -3.628 at 1%, -2.950 at 5% and -2.608 at 10%.

Table 4.3: Results of Phillips-Perron Unit Root Test

Variable	Intercept		Intercept and Trend		None		Remark
	T - Stat	Prob	T - Stat	Prob	T – Stat	Prob	
Level							
REER	-2.7238	0.0720	-2.7585	0.2149	-1.0867	0.2504	
First Difference							
REER	-13.1175	0.0000	-13.1042	0.0000	-13.1530	0.0000	<i>I(1)</i>

Source: Author's Survey 2017

The Augmented Dickey-Fuller and Phillips-Perron Unit Root Tests, also referred to as the first generation tests (classical tests) cannot distinguish between unit root and near unit root stationary processes (Nyongesa, 2013). The power of the tests is low if the process is stationary but with a root close to the non-stationary boundary (1) i.e. $Y_t = 0.95Y_{t-1} + \mu_t$. The tests are poor at deciding, for example, whether $\phi = 1$ or $\phi = 0.95$, especially with small sample sizes. The study therefore also employed the second generation unit root tests, which included Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test of Kwiatkowski *et al.*, (1992) and Elliot-Rothenberg-Stock unit root test.

4.5.3 KPSS and Elliot-Rothenberg-Stock Test

Results of KPSS unit root tests are presented in table 4.5. Results were estimated with Newey-West Bandwidth automatic selection using Bartlett Kernel. The aim for this test is to remove deterministic trend of the series in order to make it stationary.

Table 4.4: Results of KPSS and Elliot-Rothenberg-Stock Test

	<u>Kwiatkowski-Phillips-Schmidt Shin Test</u>			<u>Elliot-Rothenberg-Stock Test</u>		
	Intercept	Intercept with Tend	Intercept	Intercept Trend	with	Remark
	<i>Level</i>					
REER	0.4749	0.1218	4.8292	7.7434		
	<i>First Difference</i>					
REER	0.4154	0.0308	0.2784	1.0372		<i>I(1)</i>

Source: Author's Survey 2017

Similarly results of Elliot-Rothenberg-Stock that were estimated with Schwarz Information Criteria (SIC) showed that real effective exchange rate was not stationary thereby supporting first generation unit root test. The results of first difference series showed that the variables became stationary. Therefore it was concluded that the study variables were integrated of the order one denoted $I(1)$. This supports prior empirical studies (Nyongesa 2013, Lutkepohl, 2005; Hamilton, 1994; Enders, 2015 among others) and econometrics theory that indicates that macroeconomic variables were not stationary in levels but become stationary on first differencing (Greene 2012, Cameron and Trivedi 2005, Cameron and Trivedi 2005, Baum 2012, Gujarati, 2012 Wooldridge 2012).

4.6 Unit Root Tests with Structural Breaks

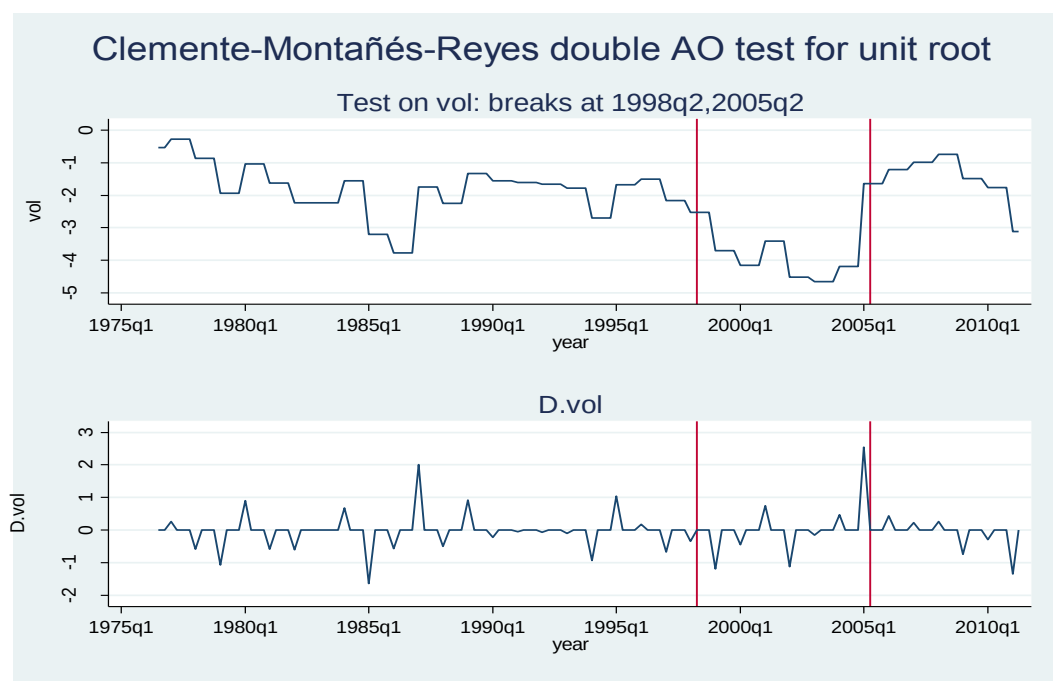
The next step of the analysis was testing for unit root with structural breaks and results are presented in table 4.6.

Table 4.6: Unit Root Test with Structural Breaks

Variable	Breaks	Coef	T-Stat	P-Value	Year
REER	<i>D1</i>	-2.1547	-12.120	0.000	1998q2
	<i>D2</i>	1.9216	9.413	0.000	2005q2

Source; Author's Research, 2017

543 Real effective exchange rate had first significant structural break in 1998q2. This structural break
544 was positive and significant ($p - \text{value } 0.000 < 0.05$). So to 2005q2 ($p - \text{value } 0.000 < 0.05$).



545
546 Source: Author's Survey, 2017
547 Figure 4.11: Plots of Structural Breaks of REER

549 4.8.1 Variance Decomposition

550 Variance decomposition shows the contribution of each shock to the n -period-ahead forecast error of
551 the variable. It typically shows the proportion of the forecast error variance which can be attributed
552 to its own shocks and the innovations that emanate from other variables in the model. The results of
553 variance decomposition for real effective exchange rate are reported in Table 4.17. From the results
554 it is seen that REER is 100 per cent explained by its own innovations in the first period, but its
555 explanatory power declines over time to 93.7 per cent during the 10-th period.

556 **Table 4.17: Variance Decomposition of REER**

Period	S.E.	Variance Decomposition of REER:			
		REER	GDPR	FDIR	CABR
1	0.000418	100.0000	0.000000	0.000000	0.000000
2	0.000574	99.94756	0.000227	0.037482	0.014736

3	0.000678	99.54139	0.053117	0.196251	0.209242
4	0.000756	98.80389	0.180308	0.422707	0.593099
5	0.000817	97.89138	0.339281	0.647568	1.121766
6	0.000866	96.91193	0.497266	0.837670	1.753131
7	0.000907	95.92543	0.637031	0.985802	2.451736
8	0.000940	94.96360	0.751859	1.096083	3.188456
9	0.000968	94.04353	0.840991	1.175852	3.939628
10	0.000991	93.17470	0.906686	1.232304	4.686305

Source: Author's Survey, 2017

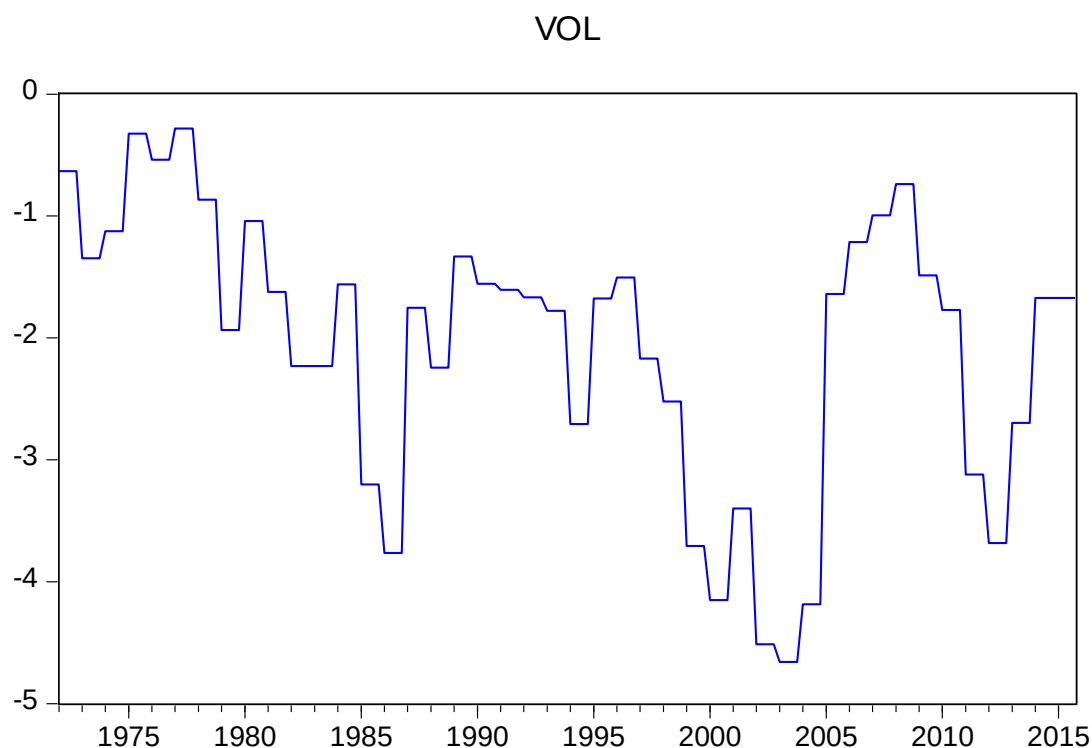
4.8.2 Impulse Response

These impulses are derived using a recursive VAR model, in which Cholesky one-standard deviation shocks are applied and the response is estimated over a period of ten years following the initial occurrence of the shocks. The impulse response function of VAR is to analyze dynamic effects of the system when the model received the impulse. Results of the impulse response analysis indicate the reaction of REER volatility due to one standard deviation of unanticipated positive shock to itself – a steady decline in Kenya's REER volatility. The dashed line shows that the positive shock to REER volatility is transmitted almost completely to REER itself. There is a revelation of a persistently sharp decline in REER volatility. Asymptotically, it will converge to the equilibrium in the long run.

4.11 Nature of Real Effective Exchange Rate

The study sought to determine the nature of real effective exchange rate in Kenya. To achieve this objective the first hypothesis stated that real effective exchange rate in Kenya has not been volatile. The GARCH model was estimated since it was feasible and has remained the workhorse for estimation of volatility.

580 **Figure 4.8: Plot of REER Volatility in Kenya**



581
582 Source: Author's Survey, 2017

583 The generalized ARCH (p,q) model – called GARCH(p,,q) – allows for both autoregressive and
584 moving average components in the heteroskedastic variance. If we set p=0 and q=1, it is clear that
585 the first-order ARCH model given by (3.28) is simply a GARCH (1,1) model. Similarly, if all values
586 of β_1 equal zero, the GARCH (p,q) model is equivalent to an ARCH(q) model. The benefits of the
587 GARCH model should be clear; a high-order ARCH model may have a more parsimonious GARCH
588 representation that is much easier to identify and estimate (Enders, 2015). This is particularly true
589 since all coefficients in (3.10) must be positive. Clearly, the more parsimonious model will entail
590 fewer coefficient restrictions. Moreover, to ensure that the variance is finite, all characteristic roots
591 of (3.10) must lie and imply that the process is stable (Enders, 2015).

592
593 The key feature of GARCH models is that the conditional variance of the disturbance of the (y_t)
594 sequence acts like an ARMA process. Hence, it is to be expected that the residuals from a fitted
595 ARMA model should display this characteristic pattern. To explain, suppose you estimate (y_t) as an
596 ARMA process. If your model of (y_t) is adequate, the ACF and PACF of the residuals should be
597 indicative of a white-noise process. However, the ACF of the squared residuals can help identify the

order of the GARCH process. Equation (3.10) looks very much like a standard ARMA (p,q) process. As much, if there is conditional heteroskedasticity, the correlogram should be suggestive of such a process.

Results of real effective exchange rate are presented in Table 4.25. Results indicated that the GARCH (1,1,1) selected by AIC and BIC model fitted the data very well R-Square was 0.8642756 indicating that the model explained 86.43 percent, log likelihood was also a large number 92.34 > 30. Based on the results, the first null hypothesis that real effective exchange rate in Kenya has not been volatile is rejected. Results indicated that real effective exchange rate in Kenya was volatile (p – value $0.000 < 0.05$) within the period under consideration (1972q1 – 2015q4).

Exchange rate stability is conducive to macroeconomic performance growth through its positive impact on investment and promotion of trade. Stable exchange rate decreases price uncertainty and real interest rate volatility and therefore the efficiency of price system at international level and promotes economic stability and growth. It was therefore concluded that real effective exchange rate in Kenya has been volatile.

Table 4.5: GARCH Results on Real Effective Exchange Rate

Sample Period	1973q1 - 2015q4			
Number of observations	172			
Log likelihood	-92.341568			
R-squared	.8642756			
Adjusted R-squared	.86347722			
Root MSE	41635337			
Variable	Coef.	Std. Error	t – Value	P> t
REER L1	0.9255271	0.0281299	32.90	0.000*
Constant	-0.1612711	0.0666751	-2.42	0.017*
AIC	188.6831			
BIC	194.9781			

Source; Author's Research, 2017

5.2 Conclusion and Policy Recommendations

The findings of this study exhibit some important implications for policymakers in Kenya and other developing countries of similar characteristics and stage of development. The findings indicate that REER volatility is a persistent feature of the Kenyan economy and that policy interventions are useful in addressing or containing the adverse shocks to the economy from REER volatility.

The findings of the volatile REER imply that, regular and persistent REER volatility may trigger financial crisis in the long run. In other words, the REER volatility path may be used as an indicator to predict financial crises and international competitiveness. Therefore, the policy implication arising from this analysis is that Kenya should implement policy measures to correct her unsustainable external imbalances in the long run.

There is need to apply the appropriate macroeconomic policy mix in the short run to mitigate the cyclical and short-term shocks that arise from REER volatility. However, to ensure that there is external stability in the long run, policies regarding structural improvement, such as export competitiveness enhancement, second stage import substitution and research and development, should be addressed.

The key policy implication of the findings about the REER volatility is that prudent management of the exchange rate stability must be pursued. This will help reduce the exchange rate volatility associated with major trading partners. There is need to focus on the terms of trade in order to have a positive impact on the current account balance. On the other hand, inflation should be contained to levels that are productive without affecting the economic growth and current account deficit.

REFERENCES

- Arize, A. C., Osang, T., & Slottje, D. J. (2000). Exchange-rate volatility and foreign trade: evidence from thirteen LDC's. *Journal of Business & Economic Statistics*, 18(1), 10–17.
- Aseidu, E. (2003), (2001) 'On the Determinants of Foreign Direct Investments to Developing Countries: Is Africa Different?' *World Development* 30(1), 107- 119.
- Baum C. (2012). *Time Series Analysis using STATA*, MIT. USA
- Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 31(3), 307–327.
- Cameron and Trivedi (2005). *Microeconometrics Methods and Techniques*, MIT Prss
- Darrat, A. F., & Hakim, S. R. (2000). Exchange-rate volatility and trade flows in an emerging market: some evidence from a GARCH process. *Savings and Development*, 287–302.
- De Grauwe, P. & Schnabl, G. (2004). Exchange rate regimes and macroeconomic stability in Central and Eastern Europe. 3(2), 3–11.
- Dornbusch R.(1976) - Expectations and exchange rate dynamics. *Journal of political economics* 84(6), 1161-1176.
- Dornbusch, R.(1980). - Exchange rate Economics: Where do we stand? . *Journal of political economics* 84 (3), 677 - 700.
- Edwards, S. (1988). Real and monetary determinants of real exchange rate behavior: Theory and evidence from developing countries. *Journal of Development Economics*, 29(3), 311–341.
- Edwards, S., & Savastano, M. A. (1999). *Exchange Rates in Emerging Economies: What do we know? What do we need to know?* National Bureau of Economic Research.
- Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *econometric: Journal of the Econometric Society*, 987–1007.
- Frankel, R., & Rose. (2002). An estimate of the effect of common currencies on trade and income. *Quarterly Journal of Economics*, 437–466.
- Frenkel, J. A., & Goldstein, M. (1986). *A guide to target zones*. National Bureau of Economic Research. 41(1), 66–82.

- 674 Friedman, M. (1953). The methodology of positive economics. *Essays in Positive Economics*, 3(3).
675 30 - 43.
- 676 Greene W. H. (2013). *Econometric Analysis*, Prentice Hall USA
- 677 Gujarati D. (2012). *Basic Econometrics*,
- 678 Gylfason. T. (2000). Resources, agriculture, and economic growth in economies in transition.
679 *Kyklos*, 53(4), 337–361.
- 680 Johansen, S and Juselius, K (1990). “Maximum likelihood estimation and inference on
681 cointegration-with the application to the demand for money”, *Oxford Bulletin of Economics*
682 *and Statistics*, vol. 52, pp. 169-210.
- 683 Kiptoo, C. (2007). Real Exchange Rate Volatility, and misalignment in Kenya, 1993-2003,
684 Assessment of its impact on International Trade, and investments, unpublished. *University of*
685 *Nairobi*.
- 686 Kiptui, M., & Kipyegon, L. (2008). External Shocks and Real Exchange Rate Movements in Kenya.
687 In *presentation at the 13th Annual Conference on Econometric Modeling in Africa*,
688 *University of Pretoria* (pp. 9–11).
- 689 Kiyota, K. and Urata, S., (2004). “Exchange rate, Exchange rate volatility and Foreign Direct
690 Investment”, *The World Economy*, Wiley Blackwell, Vol.27(10), pp 1501-153
- 691 Lutkepohl H. (2005). *Introduction to Multiple Time Series Analysis*. Springer Verlag. Berlin
- 692 Mambo, E. (2012) -Non small cell lung cancer (NSCLC) is the leading cause of cancer-related
693 mortality world-wide and the majority of cases are diagnosed at late stages of disease. 627–
694 896.
- 695 *Marrinan J (1989) Isolation of hem3 mutants from Candida albicans by sequential gene disruption.*
696 *8(5), 45-6*
- 697 McKinnon, R. and Ohno, K., (1997). Dollar and Yen, resolving economic conflict between the
698 United States and Japan, Cambridge, MA, USA: MIT press Mckinnon, R., (1963) Optimum
699 currency areas”. *American Economic Review*, vol 53, 717-724.
- 700 Mckinnon, R., (1963). Optimum currency areas”. *American Economic Review*, vol 53, 717-724.
- 701 Mwega, & Ngugi. (2006). Foreign direct investment in Kenya. *Foreign Direct Investment*.
- 702 Ndung’u, N. (2000). *The exchange rate and the interest rate differential in Kenya: a monetary and*
703 *fiscal policy dilemma*. Kenya Institute for Public Policy Research and Analysis.

- 704 Ndung'u, N. S. (1997). *Price and Exchange Rate Dynamics in Kenya: An Empirical Investigation*.
- 705 Nyongesa, D.N (2013). *Determinants of Current Account Deficit and its Sustainability in*
706 *Kenya*. Maseno University, Kenya.
- 707 Obstfeld and Rogoff 1996 -Foundations of International Macroeconomics, 87(23), 1176–1382.
- 708 Pagan, A., & Ullah, A. (1988). The econometric analysis of models with risk terms. *Journal of*
709 *Applied Econometrics*, 3(2), 87–105.
- 710 Pollin, R., & Heintz, J. (2007). *Expanding decent Employment in Kenya: The Role of Monetary*
711 *Policy, Inflation Control and the Exchange Rate*. Political Economy Research Institute,
712 University of Massachusetts at Amherst.
- 713 Rose, A. (2002). An estimate of the effect of common currencies on trade and income. *Quarterly*
714 *Journal of Economics*, 437–466.
- 715 Stratlink,. (2012). *Agricultural Marketing and Trade and Wealth Creation*.
- 716 Were, M., Ndung'u, N. S., Geda, A., & Karingi, S. N. (2002). *Analysis of Kenya's Export*
717 *Performance: An Empirical Evaluation*. Kenya Institute for Public Policy Research and
718 Analysis.
- 719 Williamson, J., & others. (1985). *Exchange rate system*. Institute for international economics.
- 720 Wright, S. C., Aron, A., McLaughlin-Volpe, T., & Ropp, S. A. (1997). The extended contact effect:
721 Knowledge of cross-group friendships and prejudice. *Journal of Personality and Social*
722 *Psychology*, 73(1), 73.

723