

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 scanty information 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. It was found that real effective exchange rate in Kenya has been volatile within the period under consideration. These findings 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, Generalized Autoregressive Conditional Heteroscedasticity, International Competitiveness.

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

41 rate (NEER) is the rate of one currency against a weighted composite basket of the country's trading
42 partner currencies. When NEER is adjusted for inflation, it becomes the real effective exchange rate
43 (REER) which was the focus of this study. Kenya trades with more than one country, hence, the
44 need to focus on the composite basket of trading partner currencies.

45
46 The exchange rate is measured as a unit of domestic currency vis-à-vis a unit of the US Dollar. This
47 is measured in real terms as the real effective exchange rate (REER). This is the most appropriate
48 measure of the real exchange rate for a study of this nature given its ability to capture and measure
49 the international competitiveness of countries. Moreover, it has been weighted by the level of trade
50 and investment between each country and the rest of the world (Kiyota and Urata, 2004). This has
51 the advantage of eliminating the bias of the sample towards actual investors when bilateral exchange
52 rates are used and account as much as possible for potential investors in the sense that investors,
53 actual and potential, are more likely to come from countries that are already in a trading relationship
54 with the country in question.

55
56 Real Effective Exchange Rate (REER) volatility refers to short term fluctuations of the REER about
57 their longer term trends (Frenkel and Goldstein, 1986). It also entails short-term (monthly, weekly,
58 or even hourly) fluctuations in the exchange rates as measured by their absolute percentage changes
59 during a particular period (Williamson et al., 1985). Increased, REER volatility may lead to higher
60 prices of internationally traded goods by causing traders to add a risk premium to cover
61 unanticipated exchange rate fluctuations (McKinnon & Ohno, 1997; McKinnon, 1963).

62
63 The exchange rate is used as a parameter for determining international competitiveness, and it is
64 regarded as an indicator of the competitiveness of the currency of any country and that an inverse
65 relationship between this competitiveness exists. To this end, the lower the value of this indicator in
66 any country, the higher the competitiveness of the currency of that country will be. In other words,
67 the real exchange rate plays a crucial role in guiding the broad allocation of production in the
68 domestic economy and spending between foreign and domestic goods. [The real exchange rate's
69 level, about an equilibrium real exchange rate level, and its stability have been shown to importantly
70 influence export growth, consumption, resource allocation, employment and private investments
71 (Wright, Aron, McLaughlin-Volpe and Ropp, 1997). There is need to carry out an assessment of the

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72 REER because it plays an important role in an economy. The appropriate real effective exchange
73 rate is one that does not wonder too far from its equilibrium value.

74
75 Advocates of fixed exchange rate argue that the exchange rate stability enhances cross-border trade
76 and provides an attractive environment for the flow of international capital like foreign direct
77 investment (FDI), and eventually stimulates economic growth. In their view, volatile and
78 unpredictable fluctuations of the exchange rate may lead to many harmful macroeconomic
79 consequences such as volatility of prices and output, deterioration of total exports as well as
80 worsening the external competitiveness (Gylfason, 2000; Rose, 2000; Frankel & Rose, 2002; and De
81 Grauwe & Schnabl, 2004). On the other hand, proponents of floating exchange rate regime believe
82 that exchange rate flexibility helps automatic balance of payments adjustments in response to
83 external shocks and positively influence the trade volume and economic growth (Friedman, 1953
84 ;Aseidu, 2001; and Aseidu, 2003).

85
86 Like other developing countries that face the challenge of improving the balance of payments and
87 stimulating economic growth, Kenya has adopted some different exchange rate regimes over the last
88 five decades. From a fixed exchange rate regime up to 1982 to crawling peg during the period 1983
89 to 1993 before a floating exchange rate regime was adopted in 1993. Following the liberalization of
90 the foreign exchange market, Kenya attained monetary independence to control inflationary
91 pressures but lost the nominal anchor to tie down domestic prices, and thus globalization effects are
92 transmitted directly into the country through exchange rate volatility (Kiptui & Kipyegon, 2008).
93 External shocks require appropriate fiscal and monetary policies to prevent the emergence of
94 unsustainable current account deficits, growing foreign debt burdens and steady losses of
95 international competitiveness while at the same time keeping the domestic rate of inflation at low
96 levels, conducting a strict monetary policy stance and maintaining positive real interest rates. This
97 has been difficult in practice.

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98
99 Measuring exchange rate volatility is one of the controversial issues in the recent economic
100 literature. Several measures of volatility have been employed in the literature, including standard
101 deviations and Autoregressive Conditional Heteroscedasticity (ARCH) techniques. However,
102 methods based on standard deviation suffer from many shortcomings. First, the standard deviation
103 measures of exchange rate volatility ignore relevant information on the random process that

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

118

119

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

133

134 Balance of payments deficits have been a common phenomenon in the Kenyan economy from the
135 1960s. The government has over the years enacted various policy measures aimed at remedying the
136 situation; however the balance of payments situation does not seem to have improved despite this
137 policy measures (Mwega & Ngugi, 2005.) . The deficit in the current account widened from a deficit
138 of Ksh. 76.4 billion in the first quarter of 2011 to a deficit of 81.1 billion in the first quarter of 2012.
139 The deterioration in the current account was mainly as a result of 20.8 per cent widening of the
140 merchandise account deficit (Mwega & Ngugi, 2005.) .

141 Kenya's overall balance of payments positions declined by US\$ 220.7 million from a surplus of US\$
142 360million in May 2011 to a surplus of US\$ 139 million in May 2012 (Stratlink, 2012). The
143 deterioration was largely due to narrowing of the current account. The current account deficit nearly
144 doubled to 13.1% of GDP. Imports grew by almost 20%, while exports increased by 10%, thus
145 representing a net export of -10%. Import growth was mainly driven by oil imports, which accounted
146 for 27.6% of the total import bill in 2011, jumping from US\$ 2.7 billion (8.9% of GDP) in 2010, to
147 USD 4.1 billion (11.6% of GDP) in 2011 (Stratlink, 2012).

148
149 Uncertainty stemming from a previous balance of payments position continues to suppress economic
150 growth prospects. The country has a gaping current account deficit and with only \$3.7 billion in
151 foreign exchange reserves – enough to cover a mere 3.44 months of imports – leaving the balance of
152 payments in a shaky position (Stratlink, 2012). The latest Central Bank of Kenya (CBK) weekly
153 bulletin shows that the usable official foreign exchange reserves held by the bank marginally
154 increased from \$ 3.711 billion, which is equivalent to 3.44 months of imports in the week ending
155 December 2012. CBK is required to maintain foreign exchange reserves equivalent to four months
156 of import cover. For low to medium income oil-importing countries such as Kenya, the current
157 account deficit should be within five to eight per cent band that is considered sustainable.

158 Despite rapid economic growth experienced between 1963 and 1970, the current account balance of
159 payments remained in deficit except in 1963, 1964, 1965, 1977, 1993, 2003, 2009, and 2010 when it
160 recovered a surplus of US\$ 10.1m, US\$ 50.6m, US\$ 0.5m, US\$ 25.9m, US\$ 124.5m, US\$ 132.4m,
161 US\$ 9908.3m, and US\$ 11404.95m respectively. The adjustments in balance of payments in Kenya

162 appears to be complicated because the receipts and expenditures are mostly financial and seldom in
163 real assets (Sifunjo, 2011).

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

178
179 A number of researchers have argued that real exchange rates are crucial not only for attaining
180 sustained general economic performance and international competitiveness, but have a strong impact
181 on resource allocation amongst different sectors of the economy, foreign trade flows and balance of
182 payments, employment, structure of production and consumption and external debt crisis (Edwards,
183 1988; Edwards & Savastano, 1999).

184
185 Recently, however, volatility increased posing challenges for macroeconomic management in Kenya
186 (Kiptui & Kipyegon, 2008). Kenya, like other developing countries, has experienced a combination
187 of exogenous shocks such as worsening terms of trade mainly on account of fluctuations in
188 international commodity prices, oil price shocks and volatility in capital flows, which have created
189 macroeconomic management policy challenges. Therefore, understanding the nature of exchange
190 rate volatility would help in guiding appropriate exchange rate policies that foster exports'
191 competitiveness, attract foreign financial sources such as FDI, improving the balance of payments
192 and stimulating economic growth.

193

194 **1.1 Theoretical Framework**

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

202

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

210

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

216

217 Because of the sluggish adjustment of the national price level, a purely nominal shock or disturbance
218 can cause short-run deviations from PPP and overshooting of the nominal exchange rate (McDonald,
219 1988). Hence the model is popularly known for its demonstration of overshooting (and
220 undershooting) behavior in exchange rates (Dornbusch, 1976 ;Marrinan, 1989; Obstfeld and Rogoff,
221 1996).

222

223 The consequences for the short run behavior of the exchange rate, given imperfect price flexibility,
224 are to generate ‘over – shooting’. That is, given an initial disturbance, the exchange rate first moves
225 beyond its long run equilibrium level, and then in the longer run moves back. This provides an
226 explanation of an empirical phenomenon which attracted much attention in the late 1970s and early
227 1980s. In particular, it was the common experience of Switzerland, West Germany and the UK that
228 the adoption of heavily publicized strict monetary targets was followed by a substantial appreciation
229 in the real exchange rate of the respective currencies (J – curve phenomenon).

230

231 **2.0 Theoretical Review**

232 **2.1 Measuring Real Effective Exchange Rate Volatility**

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

240

241 First the long run equilibrium properties of the model are identical to those of the monetary approach
242 (Asset market equilibrium lies at the center of the model) where the asset in question is money and,
243 where the demand for money function is stable and the supply of money is determined by the
244 authorities. The economic interpretation of this is that as the exchange rate rises, aggregate demand
245 rises as net exports respond to increased competitiveness. Thus is offset by a rising price level which
246 reduces aggregate demand via two mechanisms. First, the increased price level reduces
247 competitiveness and therefore net exports. Secondly, the increasing of the price level also has the
248 effect of reducing the real money stock, therefore increasing the domestic interest rate (the ‘Keynes
249 effect’) which also reduces aggregate demand (Dornbusch, 1988).

250

251 The Dornbusch model is interesting for its properties of dynamic adjustment, once the crucial
252 assumption is made that asset markets adjust more quickly than do goods markets and that in the

253 short run, the price level is sticky, while goods prices are fixed in the short run and only adjust
254 gradually in the long run. Thus, an increase in the money stock increases real income in the short
255 run, both because of the fall in the interest rate and because of the (overshooting) the rise in the real
256 exchange rate. In this guise, it is tempting to see the Dornbusch model as reconciliation between
257 Mundel – Fleming as a short run exercise, and the monetary approach as the long run equilibrium to
258 which it tends.

259
260 Despite its popularity, the Dornbusch model has methodological limitations when examined from
261 micro-foundation perspective. First, the model lacks explicit choice-theoretical foundations,
262 particularly concerning micro-foundations of aggregate supply (Obstfeld & Rogoff,1996). Its
263 specification of the price determination is ad hoc. The model also is ill-equipped to capture current
264 account dynamics or the effects of government spending, since it does not account for private or
265 government inter-temporal budget constraints (Obstfeld & Rogoff, 1996). In addition, it does not
266 explicitly model the implicit bond market. Nevertheless, the model has played a dominant role in the
267 literature on exchange rate dynamics and remains one of the basic building blocks of open economy
268 macro-models.

269 270 **3.0 Methodology**

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

275
276 To overcome the methodological deficiencies of standard deviation methods, the study used the
277 Generalized Autoregressive Conditional Heteroscedasticity (GARCH) developed by (Bollerslev,
278 1986) The advantage of the GARCH method over the standard deviation measures is their ability
279 to discriminate between predictable and unpredictable elements in the exchange rate formation
280 process, and therefore, they serve as accurate measures of volatility (Arize et al., 2000 and Darrat
281 & Hakim, 2000).

282

283 The proposed study investigated the relationship between exchange rate volatility and
 284 macroeconomic performance in Kenya, focusing on some selected macroeconomic indicators,
 285 namely; economic growth, foreign direct investment, and current account balances during the period
 286 1972q1 – 2015q4. The study measured the real effective exchange rate (REER) volatility using the
 287 Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model. The Vector Error
 288 Correction Model was used to establish the impact of exchange rate volatility on those selected
 289 macroeconomic indicators.

290
 291 Therefore, the conditional variance of GARCH model could be specified as follows:

292

$$293 \quad \ln REER_t = \alpha_0 + \alpha_1 \ln REER_{t-1} + e_t; \text{ where } e_t \sim (0, h_t) \dots\dots\dots (1)$$

$$294 \quad h_t = \alpha + \beta e_{t-1}^2 + \gamma h_{t-1} + \mu_t \dots\dots\dots (2)$$

295
 296 This equation means that the conditional variance is a function of three terms: the mean, α ;
 297 information about volatility from the previous period, measured as the lag of the squared residual
 298 from the mean equation e_{t-1}^2 (the ARCH term), and the variance of previous period's forecast error,
 299 h_t (the GARCH term). Accordingly, we will estimate GARCH (1,1) conditional variance on quarterly
 300 real effective exchange rate (REER) over the period 1972-2015.

301

302 **3.1 Data Type and Sources**

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

307

308 The data on REER included trade volume with major trading partners, real bilateral exchange rate,
 309 foreign price index calculated as the weighted **Consumer Price Index** (CPI) and the domestic CPI.

310

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

314

315 3.2 Measurement of Variables

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

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

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

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

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

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

330 3.3 Integration properties (Unit root test)

331 The Classical Econometric Theory assumes that observed data are usually stationary in nature,
332 whereby means and variances are constant overtime (Engle and Granger 1987). However, the
333 estimates of time series econometric models and historical records of economic forecasting
334 invalidate such assumptions. To avoid spurious regression results, stationarity is important for
335 empirical modeling.

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

341 property that a time series variable possesses a finite mean, variance, and autocovariance function
342 that are all independent of time (Nyongesa D., 2013).

343 As is common in time series analysis, before estimating our regression models, all series require to
344 be tested for the unit root to avoid the spurious regression. Therefore, the analysis started with
345 identifying the order of integration of the variables, using Augmented Dickey-Fuller (ADF), Philips-
346 Perron (PP) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests for a unit root. Since the
347 unit root tests are sensitive to the lag length, the study uses the Akaike Information Criterion (AIC)
348 to select the optimal lag length. The study utilized the quarterly time series data covering the period
349 1972-2015.

350

351 3.4 Cointegration Analysis

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

363

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

$$365 \Delta \varepsilon_t = \mu \varepsilon_{t-1} + \sum \mu_i \Delta \varepsilon_{t-i} + \mu + \delta_t + s_t \dots\dots\dots (3)$$

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

367 The residual based on ADF test for cointegration assumes that all the variables in the Ordinary Least
368 Square (OLS) equation are all integrated of order one (1) such that the cointegration test gears to
369 establish whether the error term is integrated of order one $\varepsilon_t \sim I(1)$ against the alternative that is
370 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.

3.5 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.

Comment [u3]: The sections dealing/mentioning Cointegration Analysis and Error Correction Model are deleted from this paper.

3.4 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 4 below.

$$NEER = \sum_{it}^n ER_{it} * W_{it} \dots \dots \dots (4)$$

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 4 is computed as follows

$$ER_{it} = \left[\frac{NER_C}{NER_{t=0}} \right] * 100 \dots (5)$$

Where, the NERC 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 (4) 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:

$$w_{it} = \left[\frac{\sum (X_{it} + m_{it})}{\sum (X_t + m_t)} \right] \dots (6)$$

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 5 and equation 6 using the following formula.

$$NEER_t = \sum_{it}^n ER_t * W_t \dots (7)$$

Where ER_t is the bilateral exchange rate (equation 5) and W_t is the bilateral trade weight, n is the total number of countries which is 50. Based on (equation 7) 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:

$$REER_t = NEER_t \left[\frac{P_{wt}}{P_{dt}} \right] \dots \dots \dots (8)$$

Where P_{dt} is the price level in Kenya (domestic price) proxied by consumer price index (CPI) at time t and P_{wt} 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:

$$P_{wt} = \sum_{it}^n P_{it} * W_t \dots \dots \dots (9)$$

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.

3.5 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:

$$\delta_t^2 = \alpha_0 + \alpha_1 \mu_{t-1}^2 + \mu_2 \sigma_{t-1}^2 \dots \dots \dots (10)$$

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 1 also presents the results of normality test. REER was also normally distributed with 857.5843 Jarque-Bera statistic and $p - \text{value } 0.0028 < 0.05$ indicating that it follows normally distributed.

Table 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

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The line plot displays the variable 'voll' on the y-axis against 'date' on the x-axis. The y-axis ranges from 0 to -0.005 with increments of 0.001. The x-axis ranges from 0 to 200 with major ticks at 0, 50, 100, 150, and 200. The data series is a dark blue line that starts at approximately -0.0007, fluctuates with several peaks and troughs, and reaches its lowest point of about -0.0048 around date 125. It then rises to approximately -0.0018 by date 175 and remains constant thereafter.

Comment [u4]: The plot is to be deleted and numbering of the figures revised.

4.2.1 Augmented Dickey-Fuller Unit Root Test

Table 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.

4.2.2 Results of Phillips-Perron Unit Root Test

Results of Phillips-Perron are presented in table 3 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 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-Lothenberg-Stock unit root test.

4.2.3 KPSS and Elliot-Rothenberg-Stock Test

Results of KPSS unit root tests are presented in table 4. 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: Results of KPSS and Elliot-Rothenberg-Stock Test

	<u>Kwiatkowski-Phillips-Schmidt Shin Test</u>		<u>Elliot-Rothenberg-Stock Test</u>		
	Intercept	Intercept with Trend	Intercept	Intercept with Trend	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).

4.3 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 5.

Table 5: 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

As shown in Figure 2, real effective exchange rate had first significant structural break in 1998q2. This structural break was positive and significant ($p - \text{value } 0.000 < 0.05$). So to 2005q2 ($p - \text{value } 0.000 < 0.05$).

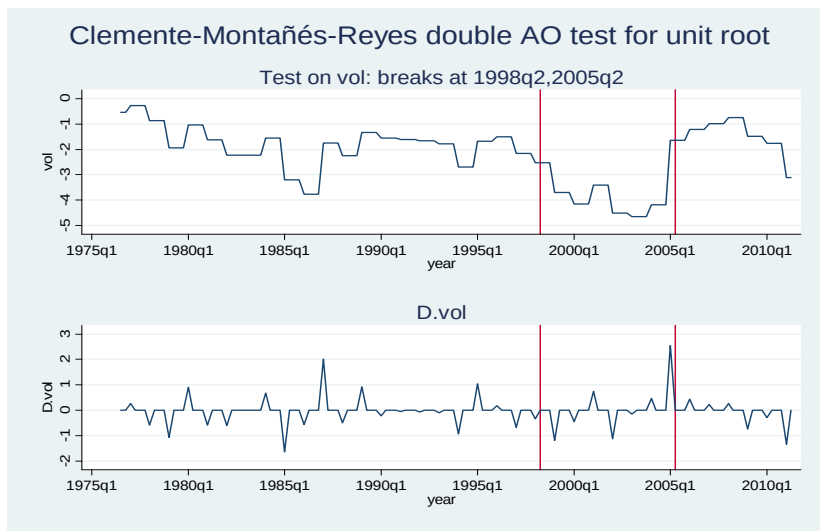


Figure 1: Plots of Structural Breaks of REER

Source: Author's Survey, 2017

4.3.1 Variance Decomposition

Variance decomposition shows the contribution of each shock to the n-period-ahead forecast error of the variable. It typically shows the proportion of the forecast error variance which can be attributed to its own shocks and the innovations that emanate from other variables in the model. The results of variance decomposition for real effective exchange rate are reported in Table 6. From the results it is seen that REER is 100 per cent explained by its own innovations in the first period, but its explanatory power declines over time to 93.7 per cent during the 10-th period.

Table 6: 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

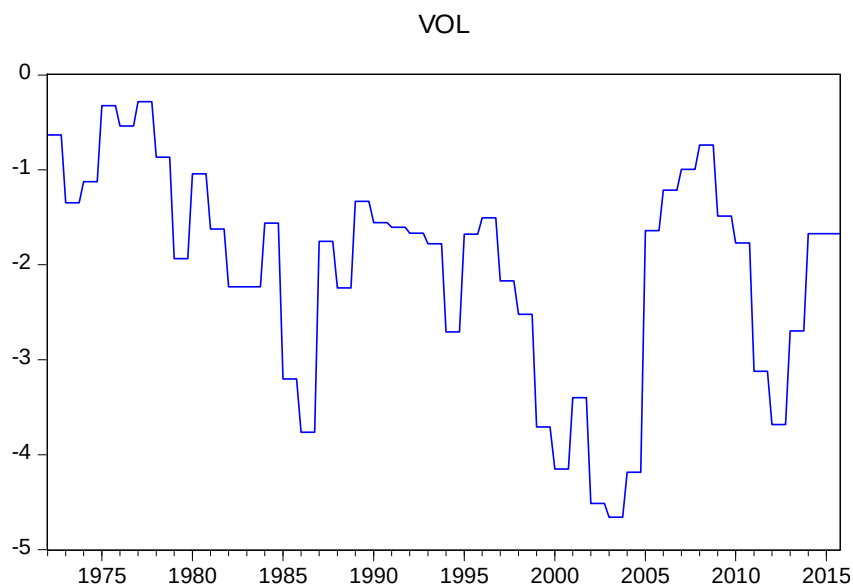
4.3.2 Impulse Response

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.

4.4 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 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.

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586 **Figure 2: Plot of REER Volatility in Kenya**

587 Source: Author's Survey, 2017

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

597

598 The key feature of GARCH models is that the conditional variance of the disturbance of the (y_t)
 599 sequence acts like an ARMA process. Hence, it is to be expected that the residuals from a fitted
 600 ARMA model should display this characteristic pattern. To explain, suppose you estimate (y_t) as an
 601 ARMA process. If your model of (y_t) is adequate, the ACF and PACF of the residuals should be
 602 indicative of a white-noise process. However, the ACF of the squared residuals can help identify the
 603 order of the GARCH process. Equation (3.10) looks very much like a standard ARMA (p,q) process.
 604 As much, if there is conditional heteroskedasticity, the correlogram should be suggestive of such a
 605 process.

606
 607 Results of real effective exchange rate are presented in Table 7. Results indicated that the GARCH
 608 (1,1,1) selected by AIC and BIC model fitted the data very well R-Square was 0.8642756 indicating
 609 that the model explained 86.43 percent, log likelihood was also a large number $92.34 > 30$. Based on
 610 the results, the first null hypothesis that real effective exchange rate in Kenya has not been volatile is
 611 rejected. Results indicated that real effective exchange rate in Kenya was volatile (p – value $0.000 <$
 612 0.05) within the period under consideration (1972q1 – 2015q4).

613
 614 Exchange rate stability is conducive to macroeconomic performance growth through its positive
 615 impact on investment and promotion of trade. Stable exchange rate decreases price uncertainty and
 616 real interest rate volatility and therefore the efficiency of price system at international level and
 617 promotes economic stability and growth. It was therefore concluded that real effective exchange rate
 618 in Kenya has been volatile.

619 **Table 7: 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

5.0 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. This is in support of the findings of various studies (Gylfason, 2000; Rose, 2000; Frankel & Rose, 2002; and De Grauwe & Schnabl, 2004).

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. This was also alluded to by Sifunjo (2011).

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. This conforms to the findings by Esteves and Reis (2006) for the Euro Area Countries. There is need to focus on the terms of trade in order to have a positive

646 impact on the current account balance. On the other hand, inflation should be contained to levels that
647 are productive without affecting the economic growth and current account deficit.
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