

Real Exchange Rate Volatility and Exports in Kenya: 2005-2012

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Abstract

The real exchange rate is an important factor in international trade because exports react to real exchange rate movements with respect to the characteristics of the importing and exporting countries. Real exchange rate volatility, therefore, increases uncertainty of profits on contracts denominated in foreign currency, subsequently dampening trade and economic growth. This study investigated how real exchange rate volatility affects export of key Kenyan commodities to the European Union and United Kingdom, namely: tea, coffee and horticulture. The presence of real exchange rate volatility was determined using the GARCH model. A bounds testing and autoregressive distributed lag model was used to establish the presence of a long run relationship between real exchange rate volatility and commodity exports. Findings reveal that real exchange rate volatility affected tea exports to the UK and horticulture exports to the European Union. Foreign income played an important role in explaining tea and coffee exports to the UK and EU, respectively. It is recommended that greater value addition be done to tea and coffee exports to ensure that their demand increases with increase in foreign incomes.

Abbreviations and Acronyms

ARCH	Autoregressive Conditional Heteroskedasticity
ARDL	Autoregressive Distributed Lag model
COMESA	Common Market for Eastern and Southern Africa
EAC	East African Community
EU	European Union
GARCH	Gross Domestic Product
GDP	Gross Domestic Product
KNBS	Kenya National Bureau of Statistics
OLS	Ordinary Least Squares
UK	United Kingdom

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1. Introduction

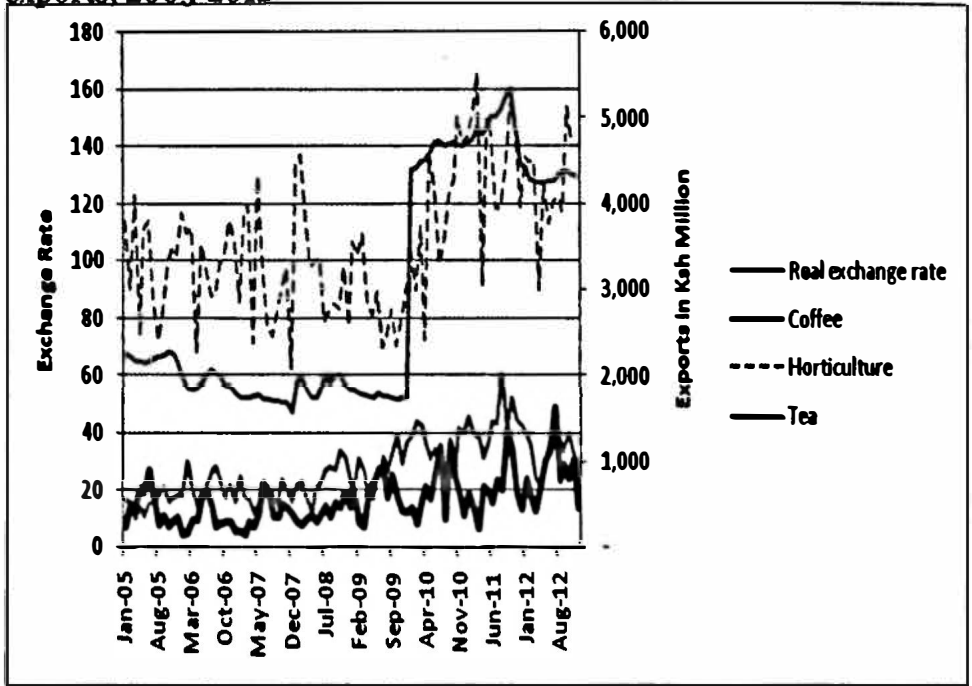
Kenya moved from a fixed exchange rate to a crawling peg regime in the early 1980s, and finally to a floating exchange rate in the early 1990s, hence providing efficient signals to both domestic and international economic agents. Real exchange rate volatility refers to short term fluctuations of the real exchange rate about their long term trends (Musyoki *et al.*, 2012). Concerns over exchange rate volatility emanate from the fact that it raises the degree of uncertainty of international trade and capital flows. It generally increases uncertainty of profits on contracts denominated in foreign currency, subsequently reducing economic growth to levels that would not have been attained in its absence (Haile and Pugh, 2011). In addition, exchange rate volatility impacts on international price competitiveness of commodities, leading to reallocation of resources among sectors, thus influencing a country's economic efficiency (Chege, Mbatia and Nzuma, 2014).

After a liberalized exchange rate was adopted in 1993, Kenya occasionally had to grapple with its adverse effects. Figure 1.1 shows that during the period under review, there have been phases of real exchange rate appreciation (January 2005 to October 2009) and depreciation (January 2010 to November 2012) coupled with episodes of wild fluctuations. On the other hand, though the value of tea, coffee and horticultural exports appear to have increased over time, there have been a number of fluctuations in terms of export earnings for the aforementioned commodities. This begs the question as to whether there is an empirical association between real exchange rate volatility and export of Kenya's key commodities.

Quite a number of studies have been carried out over the subject matter, but there is still no consensus on the effect of real exchange rate volatility on commodity exports. Some studies were unable to establish a relationship between exchange rate volatility and exports (Hondroyannis *et al.*, 2008). Others found a negative relationship between exchange rate volatility and exports (Kandil, 2009; Wang and Barrett, 2007; Berthou, 2008; Nabli and Varoudakis, 2002; and Mehare and Edriss, 2012).

Thus, this study intends to investigate the empirical relationship between real exchange rate volatility and exports of key Kenyan commodities, namely: coffee, tea and horticulture to the European Union (EU) and United Kingdom (UK). It seeks to answer the question whether real exchange rate volatility is important in explaining the value of exports in Kenya. Also, it ascertains whether different export commodities are affected differently by real exchange rate volatility. Finally, it informs the readers on whether export commodities are affected differently by the distinct features of various importing countries. The real exchange rate volatility was determined using the GARCH methodology, while the presence of a short

Figure 1.1: Real exchange rate and Kenya's tea, coffee and horticultural exports, 2005-2012



Source: CBK and KNBS

or long run relationship between real exchange rate volatility and commodity exports was done using the Autoregressive Distributed Lag (ARDL) model.

The next sub-section of this study gives an overview of exchange rate and exports in Kenya since independence, followed by the problem statement, justification and scope of the study. Section 2 provides a general review of both theoretical and empirical literature, followed by a presentation of the methodological approach in Section 3. The study results are provided in Section 4, conclusions based on the results are in Section 5 and policy recommendations based on the conclusions in Section 6.

1.1 Export Growth and Exchange Rates in Kenya

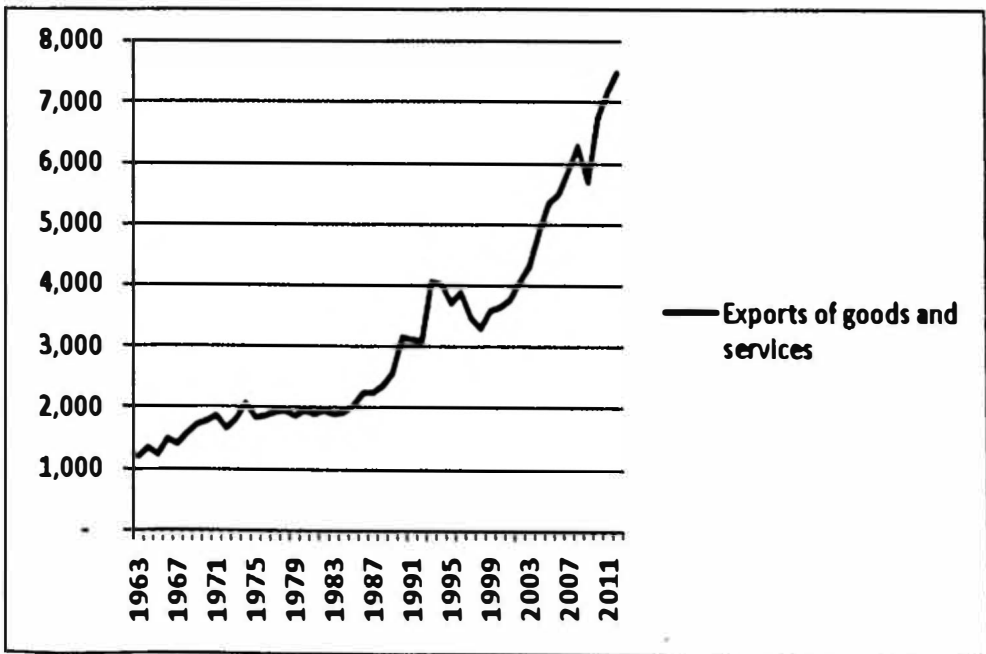
1.1.1 Exports in Kenya

Kenya's key export commodities since independence have been tea and coffee, followed by horticultural products. These three have experienced rapid growth over the last few decades. Manufactured exports still constitute a small proportion of Kenya's total exports. This situation has made the export sector vulnerable to fluctuations in world prices (Were *et al.*, 2002). The decade following

independence saw the country adopt an import substitution strategy that helped diversify the exports sector from dependence on primary commodities (Kinuthia, undated). The most prominent feature of this strategy was the high level of protection accorded to infant industries by the trade barriers in force at the time. Due to the fact that the major objective of promoting the infant industries was import substitution, most products that came from these industries targeted the domestic market to displace imports. The result was poor export performance in the country's manufacturing sector, and a bias towards production of consumer goods (Were *et al.*, 2002). This explains the low value of Kenyan exports (in US\$) in the post-independence decade (Figure 1.2).

The oil shocks of the 1970s, coupled with mismanagement of the coffee boom and the collapse of the East Africa Community (EAC), caused some acute balance of payment problems in the country. These developments prompted the country to embark on a restructuring programme meant to make the economy more competitive and reduce direct government participation in production activities. It is for this reason that in the early 1980s, the government had to shift from the import substitution strategy to an export promotion strategy that focused on gradually eliminating the anti-export bias. Based on Sessional Paper No. 1 of 1986 on Economic Management for Renewed Growth, and other national development

Figure 1.2: Kenya's exports of goods and services (in US\$ millions), 1963-2012



Source: IMF (Various), World Development Indicators

plans, trade policy reforms began in earnest in 1986 (Government of Kenya, 1986). As evident in Figure 1.2, Kenyan exports were relatively low at the time of adopting the outward-looking development strategy (Kiringai, undated, and Were *et al.*, 2002).

The economic crisis that was characterized by reduced economic performance (GDP fell from 5 per cent in 1989 to 2.1 per cent and 0.5 per cent in 1991 and 1992, respectively), budgetary and financial constraints following reduced donor funding, compelled the government to yield to donor pressure and embrace wide-ranging economic reforms. The government instituted a number of tariff reductions over the 1987-1992 period, followed by lifting of all current and capital account restrictions in 1993-1994.

Exports responded massively to the trade liberalization measures undertaken in the mid 1990s, and have been on an upward trend ever since. Though slightly affected by the global financial crisis between 2008 and 2009, exports rebounded upwards in subsequent years to an all time high. Regional integration agreements such as COMESA and EAC have resulted in an increase in Kenya's manufactured exports, and consequently total exports. The signing of the interim Economic Partnership Agreements with the EU in 2010 also contributed to growth in Kenya's export sector.

The country's exports structure has remained more or less the same over time. Tea and coffee have been Kenya's key exports since independence. Horticultural exports grew in the last few decades to be among the top three export commodities in the country. Tea, coffee and horticultural products thus remain the country's key export commodities (Were *et al.*, 2002). The three commodities, together with articles of apparel and clothing accessories, account for 47 per cent of total domestic earnings (KNBS, 2013).

According to the Economic Survey 2014 (KNBS, 2014), Kenya's leading exports' destination after the EAC is the EU. Horticulture and coffee form the bulk of Kenya's exports to the EU, while Egypt is the main export destination for Kenyan tea.

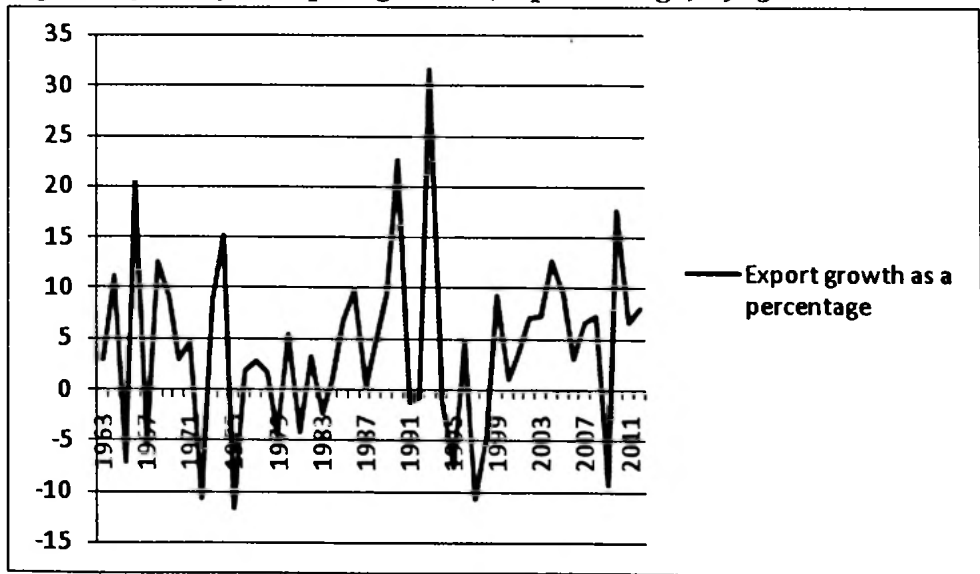
As indicated in Figure 1.3, Kenya's exports growth has been erratic as a result of fluctuations in earnings from a few traditional primary exports, and the tourism sector. Most notable is the rapid growth in exports in the 1970s attributed to the sharp increase in international prices of tea and coffee and in the early 1990s when the country adopted a liberalized trade policy (KNBS, 1977 and 1995).

1.1.2 Exchange rate policy in Kenya

Kenya's exchange rate regime since independence has been characterized by three different regimes; fixed exchange, crawling peg and the floating exchange rate era. The fixed exchange rate era was implemented from independence to 1982 before the country moved to the crawling peg era. The exchange rate controls had been instituted since the early 1970s to deal with the balance of payment crisis of 1971/1972. This move was aimed at conserving foreign exchange and managing the balance of payment pressures (Ndung'u, 1999). These controls had to be abandoned in 1982 due to frequent exchange rate depreciations and devaluations that the shilling suffered between 1974 and 1981.

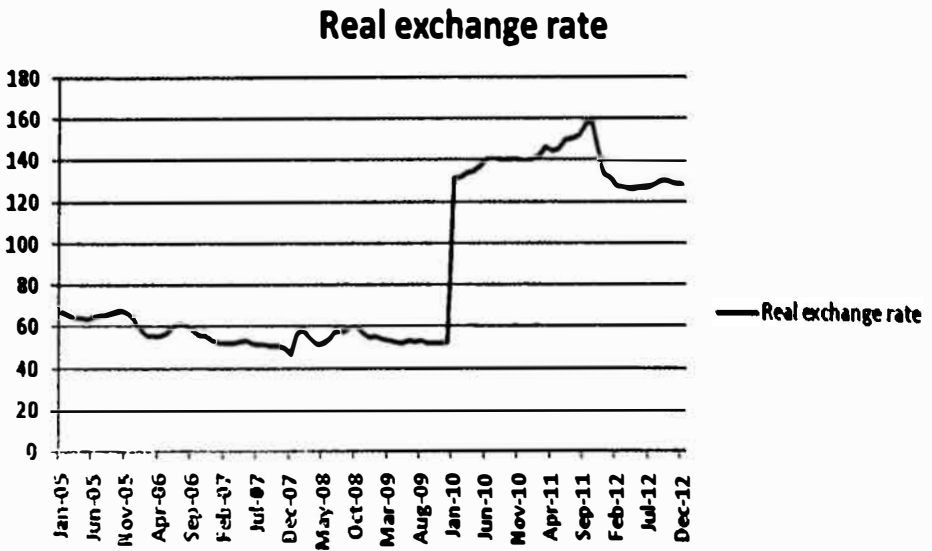
The crawling peg regime was implemented between 1982 and 1990 when a dual exchange rate regime was adopted. The official exchange rate was eventually abolished in 1993 to mitigate the problem of real exchange rate misalignment. The shilling strengthened briefly against the dollar up to 1995, then slid back into depreciation until 2004. Due to increased foreign exchange flows, growth in remittances increased export earnings, and favourable macroeconomic environment led to the shilling appreciating consistently from 2004 to 2007. This was followed by weakening of the currency from 2008 to 2011, majorly attributed to the effects of the global financial crisis (KNBS, 2012). It later on stabilized in 2012 as a result of the restrictive monetary policy stance adopted by the Central Bank of Kenya in the first half of the year (World Bank, 2013). Figure 1.4 gives a picture of real exchange rate movements within 2005-2012.

Figure 1.3: Kenya's export growth (in percentage) 1963-2012



Source: IMF (Various), World Development Indicators

Figure 1.4: Real exchange rate movement in Kenya (2005-2012)



Source: IMF (Various), World Development Indicators

1.1.3 Overview of exchange rate volatility and exports in Kenya

Trade and exchange rate liberalization served as a turning point for commodity exports in Kenya. Exchange rate liberalization was meant to salvage exports from the negative effects of frequent exchange devaluations. Exports seem to have responded well to exchange rate liberalization as evidenced from the increase in export volumes over time, irrespective of episodes of exchange rate appreciation, depreciation or volatility. Agricultural commodities, namely tea, coffee and horticultural products form the bulk of Kenya’s commodity exports. These are the products that are most vulnerable to exchange rate volatility and price fluctuations. Graphical evidence from available data seems insufficient to help the study determine whether exchange rate movements and/or volatility influence exports, more so Kenya’s key exports.

1.2 Problem Statement

Exchange rate volatility is normally considered a barrier to trade, especially for agricultural commodities such as tea, coffee and horticulture because investment decisions are made way before production and consumption decisions, and are thus not easily reversible. Biological and marketing lags force agricultural producers to commit output targets before prices and exchange rates are realized. Volatility gravely affects exporters of agricultural produce because of their limited ability to

adjust to changes in exchange rates and export prices. Firms that supply produce to markets are inelastic once production decisions in the upstream industry have been made (Bonroy *et al.*, 2007).

The negative effect of exchange rate volatility on exports arises from the fact that farmers respond to price indicators created by the market. The revenue uncertainty emanating from the high risk premium associated with volatility reduces exports because the risk averse producers are not assured of profits. This discourages production, and consequently exports and economic growth.

The purpose of this study is to empirically investigate the effects of real exchange rate volatility on Kenya's key exports. Musyoki *et al.* (2010) observed that the real exchange rates in Kenya experienced episodes of appreciation coupled with volatility within the 2005-2010 period. Amidst this, Kenya's exports earnings were erratic due to the fluctuation in earnings from primary commodities. This begs the question as to whether real exchange rate volatility affected exports during the period under consideration. Different studies arrived at varied conclusions over the subject matter. Studies such as Were *et al.* (2002), Kiptui (2008) and Chege *et al.* (2014) found a negative relationship between the variables, while Hondroyiannis *et al.* (2008) found no relationship. Bonroy *et al.* (2007) held that the effect could be positive, negative or zero depending on the exports price. This study therefore seeks to answer this controversy by empirically establishing the relationship between real exchange rate volatility and Kenya's exports.

1.3 Objectives of the Study

The overall objective of this study is to empirically establish how exchange rate volatility affects Kenya's key exports. The specific objectives are to:

- (i) Determine how key exports respond to real exchange rate volatility
- (ii) Establish the influence of foreign incomes on demand for Kenyan exports

1.4 Justification of the Study

The real exchange rate is a crucial variable that determines the country's competitiveness in the international trade arena. This is evidenced by the action taken by the Kenyan monetary authorities in 1993 to liberalize the country's exchange rate regime so as to provide efficient signals to both domestic and international agents. Given that exchange rate policy is used to mitigate the adverse effects of exchange rate fluctuations on exports growth, this study will

assist policy makers to make informed decisions on the behaviour of exchange rate policy with the aim of increasing exports as envisaged in Kenya's Vision 2030. It will thus be a vehicle through which exporters vouch for a supportive macroeconomic environment that will aid the planning of exports activities.

Furthermore, different studies on the effect of exchange rate fluctuation on exports do not give conclusive evidence on the subject matter. This study, unlike previous ones, goes further to estimate how exchange rate volatility affects Kenya's key exports to the most prominent export destinations, owing to the fact that the response of exports to real exchange rate movements depends on the distinct features of both importing and exporting countries (Berthou, 2008). The major distinction between this study and others done by Kiptui (2008) and Chege *et al.* (2014) is the use of ARDL model as opposed to the Johansen co-integration model in establishing a long run relationship between the variables.

Finally, this study will add to the body of knowledge on the subject matter by using a bilateral approach in estimating the effects of exchange rate volatility on key exports to the UK and EU.

1.5 Scope and Limitations of the Study

This study was limited to 2005 to 2012 due to unavailability of disaggregated data by export commodity to EU and UK in earlier periods. It examines Kenyan coffee and horticultural exports to the EU, and Kenya's tea exports to the UK. The study chose these destinations because they are key for the respective exports. It has to be stated that Kenya's key tea export destination is Pakistan followed by Egypt (KNBS, 2014). These two were, however, replaced by the United Kingdom due to unavailability of disaggregated data on variables such as GDP.

2. Literature Review

2.1 Theoretical Literature

Musonda (2008) postulated that the effects of exchange rate volatility can be analyzed in terms of risk or uncertainty. Exporters are either risk averse or less risk averse, and this would determine their reaction to exchange rate volatility. Chege *et al.* (2014) went further and explained that the effect of exchange rate volatility on exports can be explained by two schools of thought; the traditional and risk portfolio paradigms.

The traditional school hypothesizes that higher exchange rate volatility increases risk, thus dampening trade while the risk portfolio school holds that higher risk presents greater opportunities for profit and would thus promote trade. According to the traditional school of thought, the uncertainty of returns would result in the risk averse and risk neutral producers reallocating resources from the high risk foreign markets to the lower risk domestic markets effectively, lowering international trade (Oyovwi, 2012).

The risk portfolio theory's departure from the traditional school of thought is based on the premise that the effect of an increase in exchange rate volatility depends on the convexity of the utility function, which is in turn influenced by the firm's level of risk aversion. Highly risk averse firms will, for example, find it attractive to increase exports in the event that exchange rate volatility increases the expected marginal utility of export revenue (De Grauwe, 1987). This is termed as the income effect of exchange rate volatility. The risk seeking agents, on the other hand, consider exchange rate volatility as high risk. Increased exchange rate volatility, therefore, prompts them to reduce exports and reallocate resources to other sub-sectors. This is the phenomenon referred to as the substitution effect of exchange rate volatility. When exports increase with an increase in volatility, the greater the income effect; and if they decline with an increase in volatility, then the substitution effect will outweigh the income effect. Models of hysteresis in international trade have also shown that increased uncertainty impacts on international trade, especially if large amounts of sunk costs are involved in international transactions (Arize *et al.*, 2000).

2.2 Empirical Literature

A number of studies carried out on the subject matter observed that there has been no conclusive evidence on how the real exchange rate volatility affects exports growth (Wang and Barrett, 2007; Musonda, 2008; and Essien *et al.*, 2011). In fact, very few studies made effort to assess the role played by exchange rate

volatility on domestic macroeconomic variables, particularly exports. Essien *et al.* (2007) found that exchange rate volatility had stronger negative effects on cocoa exports in Nigeria. This conclusion was made after running an OLS regression for an export supply function for cocoa. Wang and Barrett (2007) emphasized on the importance of choice on how to proxy exchange rate risk. They indicated that a change in the expected exchange rate alongside changes in the industrial output levels mattered for trade volumes in the long run equilibrium in the Taiwanese economy. Traders responded more to changes in the expected exchange rate than actual output. Similar to Berthou (2008), the study found that trade flows were negatively affected by high frequency exchange rate volatility, and were less responsive to incomes from importers destinations than other sectors of the economy.

Hondroyannis *et al.* (2008), using a sample of 12 industrial countries to shed light on differences in results obtained by other scholars, used a different analytical framework to obtain the findings of his study. While previous studies had used time series and OLS estimation to conduct their analysis, this one extended the work of previous authors by using two additional estimation techniques, namely: GMM estimation applied to dynamic panel data specifications, and a random coefficient estimation. The authors argued that exchange rate variability could increase trade. His findings pointed that the negative and significant effect of volatility on trade could most likely have arisen from omitted variable biases or measurement error biases. Musonda (2008), after estimating an error correction model of the impact of exchange rate volatility on Zambia's non-traditional exports, showed that exchange rate volatility depressed exports both in the long and short run. He proposed that supportive macroeconomic variables be used to enhance non-traditional exports in the country.

Eichengreen and Gupta (2012) investigated the effect of exchange rate volatility on service exports in developing countries by distinguishing modern from traditional services. They found that real exchange rate affected export of merchandise and traditional services similarly, but affected modern services by a larger percentage. This is because modern services used fewer imported inputs, subsequently lowering fixed entry costs. Exports from this sector were thus more price-elastic than the others. The study pointed out that currency depreciation could be used as an instrument for growth only in the short term, because an economy could not sustain a depreciated exchange rate indefinitely.

Dincer and Kandil (2009) examined the effects of exchange rate fluctuations on disaggregated data consisting of 21 exports sectors in Turkey. The study intended to uncover the asymmetric effects of random fluctuations due to exchange rate movements on exports sectors in Turkey. It postulated that there were supply

and demand channels that followed currency appreciation/depreciation. The end result of this asymmetry would depend on which channel dominates with respect to currency appreciation/depreciation (Kandil *et al.*, 2007). Evidence from the study showed that increased contraction of export demand came as a result of currency appreciation over time. The lesser the variability of the exchange rate, the more likely it was to improve sectoral export growth in Turkey over time.

Freund and Pierola (2008) observed that export surges were associated with lower exchange rate volatility, and greater exchange rate depreciation influenced the reconstitution of production towards the most efficient manufacturing industries in developing countries. Bonroy *et al.* (2007) similarly held that export price volatility had a bearing on production capacity, hence exports depending on the assumptions about export price. The study added that since exchange rate volatility increased the degree of risk for firms, it prompted risk averse firms to reduce capacity, hence exports. Liu *et al.* (2013), on the contrary, found no evidence of exports deflection after a currency appreciation.

Using a sample of 136 countries (comprising 34 high income and 102 developing), Collaceli (2008) investigated the response of exports to real exchange rate fluctuations using the gravity model of trade. Some of the variables that were considered included bilateral trade flows, importers GDP, exporters GDP, the time variable measure of trade resistance, country pair specific measures of trade resistance affecting bilateral trade, time specific effect on trade, and country year specific error. Results indicated that there were sectoral differentials in elasticities, such that differentiated sectors had greater elasticities than homogenous ones.

In Nigeria, Essien *et al.* (2011) found that exchange rate volatility was significant and impacted negatively on cocoa exports in Nigeria after running an OLS regression for an export supply function for the commodity. In addition, agricultural credit was found to have a positive effect on cocoa exports, while the relative price¹ of cocoa was insignificant relative to the quantity of exports. Collaceli (2008) found results indicating that the presence of credit constraints in developing countries hindered them from exporting larger trade volumes as per the results. Bonroy *et al.* (2007), through their study's findings, demonstrated that exports price volatility could either decrease, remain constant or increase production capacity, and consequently exports depending on assumptions about the exports price.

Musonda (2008) attempted to empirically assess the degree and direction of the impact of exchange rate volatility on non-traditional exports by considering

¹Relative price of cocoa refers to the ratio of export price to its domestic price.

demand for exports, real foreign income, prices of exportables abroad, and terms of trade. After running, demand factors were found not to have a significant role in the performance of Zambia's non-traditional exports. Dincer and Kandil (2009) likewise found evidence of increased sensitivity of exports demand to exchange rate appreciation.

Hondroyannis *et al.* (2008), Wang and Barrett (2007), and Musyoki *et al.* (2012) used the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) system to proxy real exchange rate volatility. The latter, in a study carried out in Kenya, got evidence that the conditional volatility of the real exchange rate depended on both domestic and external shocks, real exchange rate fundamentals and macroeconomic changes.

Fang *et al.* (2006), on the other hand, used a dynamic conditional correlation bivariate GARCH model to investigate whether foreign exchange intervention stimulated exports. Findings revealed that it was important to reduce exchange rate fluctuations due to its negative net effect on exports.

Demand factors proxied by importing country's GDP did not play a major role in the performance of Zambia's non-traditional exports. The study, therefore, concluded that Zambia was a price taker in the international export markets. Similarly, Kandil *et al.* (2007) in their study of exports and exchange rates revealed that the conflicting paths of demand and supply led to unanticipated currency appreciation insignificant in Turkey.

In Kenya, Oduor and Khainga (2010) estimated the equilibrium exchange rate to help the government make informed decisions when intervening on the foreign exchange market during episodes of exchange rate misalignment. The study found that long run household expenditure strongly influenced exchange rate variations in Kenya. The authors recommended that policies aimed at stabilizing inflationary pressures are set up.

An investigation of Kenya's export performance since independence revealed that the real exchange rate had a potent effect on export performance (Were *et al.*, 2002). Kiptui (2007) equally found that the real exchange rate had positive effects on exports in the short run, though statistically insignificant for Kenya's key export products (tea, coffee, horticulture and manufactured goods). This was done by running an ARDL model to assess the presence of a long and short run relationship between the real exchange rate and exports. In addition, the destination country's income was established to be important in explaining both the short and long run export elasticities.

Chege *et al.* (2014) concluded that exchange rate fluctuations had negative long run effects on horticultural exports, with both advocating for the use of

hedging as a means to protect exporters from the effects of volatility. The study used GARCH methodology to model exchange rate volatility and concluded that it had a negative relationship with exports of French beans to the EU.

The study advocated for the government to maintain stability and competitiveness of the exchange rate. It further added that the country should boost competitiveness and diversify its export markets, while improving on the quality of export products.

Kiptui (2008) obtained results indicating that exchange rate volatility had a negative long and short run relationship with Kenya's tea and horticulture exports. The study used the 12-months moving average of the standard deviation of absolute changes in the real effective exchange rate to model exchange rate volatility. The presence of a long run relationship between commodity exports and volatility was tested using the Johansen multivariate approach. The paper recommended the use of hedging as a means of protecting exporters from the negative effects of volatility and monitoring of the exchange rate movements to ensure stability in the exchange rates.

2.3 Overview of Literature

The literature surveyed suggests that the traditional and risk portfolio paradigms best explain the relationship between real exchange rate volatility and commodity exports since it is based on the exporter's risk attitude. The other theories such as absolute advantage, Heckscher-Ohlin, and gravity model do not provide a good account of the hypothesized relationship because they do not consider the risk element in international trade.

Quite a number of studies were conducted using panel data, while majority used time series analysis. The common factor between all these studies was the frequency of the data. The use of disaggregated data on a monthly basis has been widely used to bring out both the short and long run effects of exchange rate volatility on commodity exports. This suggests that the concept of exchange rate volatility is best captured by monthly data. Other studies, however, used annual data in the analysis.

While there are studies that used standard deviation of the exchange rate as a measure of volatility, the GARCH methodology has been widely used by most studies to establish its magnitude. Volatility was furthermore found to be sensitive to the time period and methodology of calculation. In addition, the currency being used to measure volatility was also important in determining its degree.

The ARDL model is increasingly becoming popular as a means of testing for the presence of a long run relationship between exchange rate volatility and exports. The Johansen cointegration technique is still being used, the only challenge being that it can only be applied when all the variables are integrated of the same order. The ARDL model is applicable whether the variables are $I(0)$ or $I(1)$.

There were mixed results in terms of the influence of export demand factors, especially foreign economic activity. Some studies found these variables significant, while others did not. More importantly, there were pointers towards the fact that the effects of exchange rate volatility on exports depended on the sector and export destination. There were export destinations that were more sensitive to volatility than others, and this came out explicitly in studies that approached the subject matter by identifying the export commodity as per destination.

Different from previous works, this study used the ARDL model, which can be applied to test for a long run relationship between variables that are not necessarily integrated of the same order. It is applicable whether variables are $I(0)$ or $I(1)$. Like Kiptui (2008) and Chege *et al.* (2014), the study uses monthly disaggregated data. The point of departure from Kiptui's study is the time frame, methodology and products considered in the analysis. While Kiptui (2008) looked at exports of tea and coffee between 1997 and 2007, this study investigated exports of tea, coffee and horticulture between 2005 and 2012. Secondly, while Kiptui conducted co-integration tests via the maximum eigen-value likelihood ratio test statistic to establish a long run relationship between exchange rate volatility and export of tea and coffee, this study used the ARDL model to establish a long run relationship between real exchange volatility and export of coffee, tea and horticultural products.

Finally, while Chege *et al.* (2014) considered how real exchange rate volatility affected exports of French beans from Kenya to the EU, this study investigated the effect of exchange rate volatility on export of tea to the UK, and coffee and horticulture to the EU. The presence of a long run relationship was also tested using different estimation techniques. While Chege *et al.* (2014) used the Johansen multivariate cointegration test to check for a long run relationship between real exchange rate volatility and exports of French beans, this study used the ARDL model to test for the presence of a long run relationship between real exchange rate volatility and export of tea to the UK, and coffee and horticultural products to the EU.

The aforementioned provides a basis for analysis and justifies the need for the Kenyan study. It adds to the existing body of knowledge and will be useful in guiding future researchers on methodological approaches to be explored.

3. Methodology

3.1 Bounds Testing and Autoregressive Distributed Lag Model

The ARDL model refers to a mathematical expression where the dependent variable y is partly explained by lagged values of itself, current, and successive lags of the explanatory variables. This approach has been widely used following findings by Pesaran and Shin (1999) that it was applicable, whether variables were $I(0)$ or $I(1)$.

The first step involves ascertaining that there are no $I(2)$ variables in the model, followed by conducting bounds tests for the null hypothesis of no co-integration. To achieve this, the calculated F statistic is compared to the tabulated value developed by Pesaran *et al.* (2001). For a given number of variables, lower bounds and upper bounds are provided on the critical values. If the computed F statistic falls below the lower bound, it is concluded that there is no co-integration; if it falls above the upper bound, it is concluded that there is co-integration. In the event that the computed F statistic falls between the upper and lower bounds, the test is rendered inconclusive (Pesaran *et al.*, 2001). Upon ascertaining the existence of a long run relationship, as estimated in equation 1:

$$\Delta y_t = \varphi_0 + \sum_{i=1}^{m-1} \varphi_i \Delta y_{t-i} + \sum_{j=1}^p \theta_j \Delta x_{j,t-i} + \varphi_m y_{t-m} + \theta_n x_{j,t-n} + \varepsilon_t \dots\dots\dots (1)$$

the study will test for a null hypothesis of: $H_0: \varphi_m = \theta_{jn} = 0$

against an alternative hypothesis of: $H_a: \varphi_m \neq \theta_{jn} \neq 0$

The resultant long run multiplier μ_j refers to the long run effect of a change in x_j on y and by Bardsen's transformation;

$$\mu_j = \frac{\theta_j}{-\varphi_m} \dots\dots\dots (2)$$

The long run effect can then be estimated by equation 2. The dynamics are included to ensure that the estimates are unbiased even with the presence of endogeneity amongst some variables. The lag length is determined using the Schwartz Bayesian or Akaike Information criteria.

3.2 Empirical Model

The study took a bilateral approach in estimating the effects of exchange rate volatility on key Kenyan exports. The study adopted the methodology used by Chege *et al.* (2014) and Colacelli (2008) to estimate the relationship between

exports and exchange rate fluctuations. In a study examining export responses to exchange rate fluctuations, the author used a bilateral sample of 136 countries to estimate the relationship. The ARDL model as presented in section 3.1 was used to establish the empirical relationship. The disaggregated export responses by product will inform stakeholders on how to predict the behaviour of trading partners. Kenya, being a developing country, is expected to have more export responses to exchange rate fluctuations than developed countries.

Equation 3 was run for all the three commodities: coffee, tea and horticulture.

$$\Delta \log XP_t = \alpha_0 + \sum_{i=1}^{m-1} \alpha_{1i} \Delta \log XP_{t-i} + \sum_{i=0}^{l-1} \beta_{1i} \Delta \log Y_{jt-i} + \sum_{i=0}^{n-1} \beta_{2i} \Delta \log Y_{kt-i} + \sum_{i=0}^{l-1} \beta_{3i} \Delta \log EV_{jt-i} + \sum_{i=0}^{l-1} \beta_{4i} \Delta \log RER_{jt-i} + \alpha_{2i} \log XP_{t-i} + \beta_{5i} \log Y_{jt-i} + \beta_{6i} \log Y_{kt-i} + \beta_{7i} \log EV_{jt-i} + \beta_{8i} \log RER_{jt-i} + \epsilon_t \dots \dots \dots (3)$$

XP_t represents commodity exports and will be the regressand. Similar studies have used this variable as the dependent variable in their estimation of the effect of exchange rate variability on exports. Fountas and Aristotelous (2003) and Collaceli (2008) used it to represent real exports, while estimating the effects of the European monetary system on intra-EU exports. Mehare and Edriss (2012) used it to represent the value of oilseed exports in an attempt to relate it to exchange rate variability.

Y_{jt} represents the importers GDP at time t . This is a proxy for the foreign importing countries income. Consumption of export commodities is a function of the importers income (Essien *et al.*, 2011; Hondroyannis *et al.*, 2008). Y_{kt} represents the GDP of the exporter at time t .

RER_t refers to real exchange rate and is a measure of external competitiveness (Were *et al.*, 2002). The general real exchange rate is computed as:

$$RER_t = \frac{ep^*}{p} \dots \dots \dots (4)$$

where e is the nominal exchange rate, p^* refers to the world price index (US wholesale price) and p is the domestic price (consumer price index). This variable is expected to have a direct relationship with exports with a positive sign. μ is the real exchange rate elasticity of exports and it measures the degree of responsiveness of exports to changes in the real exchange rate.

EV_t measures exchange rate volatility in time t as measured using the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model. In its simplest form, the GARCH model can be written as:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 \sigma_{t-1}^2 \dots \dots \dots (5)$$

It essentially means that the conditional variance of u at time t depends on both the squared error term in the previous period ARCH (1) and the conditional variance in the previous time period. This is what is referred to as the general GARCH (p,q) model, with p lagged terms of the squared error term and q terms of the lagged conditional variance (Gujarati *et al.*, 2009).

ε_t represents the error term.

3.3 Data Type and Sources

Tea coffee and horticultural export data was obtained from the Kenya National Bureau of Statistics, exchange rate data from the Central Bank of Kenya, and finally, foreign exchange rate and GDP data from the International Financial Statistics website.

4. Results

4.1 Descriptive Statistics

The descriptive statistics for all the variables in real terms are as presented in Table 4.1. The mean value of coffee exports to the European Union between January 2005 and December 2012 was Ksh 357 million, with a seemingly high standard deviation of Ksh 265 million. Horticulture exports to EU had a mean value of Ksh 2,240 million, with a standard deviation of Ksh 1,110 million, while tea exports to the UK had a mean of Ksh 593 million and a standard deviation of Ksh 388 million. The monthly GDPs of Kenya, UK and EU had means of Ksh 215,050, £17,910,578 and €141 (million) with standard deviations of 86,035, 5,684,341 and 52,776,383, respectively. The Kenya shilling's real exchange rate to the euro and sterling pound had means of 116.81 and 146.09, with standard deviations of 54.24 and 57.74, respectively. Coffee, tea, horticulture and EU's GDP were in millions.

4.2 Diagnostic Tests

The following diagnostic tests were conducted for the three equations: Breusch Godfrey serial correlation test, white heteroskedasticity test, and the normality test. Results for the diagnostic tests are shown in the appendix.

4.2.1 Breusch Godfrey serial correlation test

The Breusch Godfrey serial correlation tests the null hypothesis that there is no serial correlation among the residuals. In this test, an OLS regression is run and once the residuals are obtained, they are regressed against the explanatory variables.

$$u_i = \alpha_1 + \alpha_2 X_i + \rho_1 u_{i-1} + \rho_2 u_{i-2} + \dots + \rho_p u_{i-p} + \epsilon_i \dots\dots\dots(6)$$

The null hypothesis to be tested appears as: $H_0: \rho_1 = \rho_2 = \dots = \rho_p = 0$

The alternative hypothesis is: $H_1: \rho_1 = \rho_2 = \dots = \rho_p \neq 0$

This means that the residuals are not serially correlated. Upon estimation of the equation, the R^2 is obtained and if the sample is large, the formula provides that $(n-p)R^2 \sim \chi^2_p$ meaning n-p times the R^2 value resulting from equation ... follows a chi-square distribution, with p degrees of freedom. If the $(n-p)R^2$ value is larger than critical chi-square value at a given level of significance, the null hypothesis of no serial correlation is rejected, where at least one of the coefficients in equation 8 is statistical significantly different from zero (Gujarati *et al.*, 2009).

Table 4.1: Descriptive statistics

	Coffee	EU GDP	Euro	Horticulture	Kenya GDP	Pound	Tea	UK GDP
Mean	357	141	116.8052	22,400	215,050	146.09	593	17,910,578
Median	270	129	82.19692	1,800	159,306	115.48	388	17,619,670
Maximum	1240	332	219.3445	4,820	351,745	252.02	1,630	31,952,092
Minimum	69.3	82723900	64.11607	867	135,855	75.64	169	10,038,767
Std. Dev.	265	52776383	54.237	1,110	86,035	57.74	388	5,684,341
Skewness	1.384747	2.027663	0.627151	0.670986	0.557389	0.5028	0.825768	0.43492
Kurtosis	4.45868	6.690138	1.626244	2.1029	1.421	1.543	2.263627	2.415833
Jarque-Bera	39.19139	120.2512	13.84193	10.4227	14.9394	12.54	13.07927	4.39149
Probability	0	0	0.000987	0.005454	0.00057	0.0019	0.001445	0.111276
Sum	3.42E+10	1.35E+10	11213.3	2.15E+11	20644761	14025.04	5.70E+10	1.72E+09
Sum Sq. Dev.	6.66E+18	2.65E+17	279457	1.17E+20	7.03E+11	316726.9	1.43E+19	3.07E+15
Observations	96	96	96	96	96	96	96	96

Appendix Tables 4. 5 and 6 show that the probability values of the chi-square distributions in all the Breusch Godfrey serial correlation tests are larger than the 5 per cent critical values, and therefore the null hypothesis of no serial correlation cannot be rejected.

4.2.2 White general heteroskedasticity test

The White’s general heteroskedasticity involves estimating an equation for purposes of obtaining residuals as shown in equation 7.

$$Y_i = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} + u_i \dots\dots\dots (7)$$

This is followed by running an auxiliary regression such as in equation 8.

$$u_i^2 = \alpha_1 + \alpha_2 X_{2i} + \alpha_3 X_{3i} + \alpha_4 X_{2i}^2 + \alpha_5 X_{3i}^2 + \alpha_6 X_{2i} X_{3i} + v_i \dots\dots\dots (8)$$

The squared residuals from equation 9 are regressed against the explanatory variables in equation 8, their squared values and cross products. The resultant R^2 from this equation is then obtained. With a null hypothesis of no heteroskedasticity, it is demonstrated that the sample size n multiplied by R^2 from equation 10 asymptotically follows the chi-square distribution with a degree of freedom equal to the number of regressors that do not include the constant term in equation 10.

$$n.R_2^2 \sim X_{df}^2 \dots\dots\dots (9)$$

If the chi-square value obtained above exceeds the critical chi-square value at a given level of significance, it is concluded that heteroskedasticity is present. If not, then there is no heteroskedasticity, meaning that:

$$\alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = 0 \dots\dots\dots (10)$$

Looking at the probability values of the chi-square distributions in all the White heteroskedasticity tests for the three equations in Appendix 1 to Appendix 3, they are larger than the 5 per cent critical value, hence null hypothesis of homoskedasticity is not rejected.

4.2.3 Normality tests

The normality tests were conducted using the histogram test as presented in Appendix 7 to 9. The residuals appear normally distributed. The Jarque Bera tests for the three equations have a probability of less than 5 per cent and values lower than 5.99. The null hypothesis that the error terms are normally distributed can thus not be rejected.

4.3 Unit Root Tests

As shown in Table 4.2, apart from coffee which was I (0), all the other variables were I (1). The variables tea and horticulture were logged to make them stationary.

Table 4.2: Unit root tests

Variable	ADF test at levels	ADF test at first difference
Coffee	-5.219336***	N/A
Tea	-2.447438	-13.57633***
Horticulture	-2.119937	-11.81389***

Critical values: 1% level -3.510259; 5% level -2.896346; 10% level - 2.585396

4.4 Exchange Rate Volatility

Tables 4.3 and 4.4 show exchange rate volatility for the Ksh against the pound and the euro. Looking at the variance equation in Table 4.3, both the ARCH ($\text{RESID}(-1)^2$) and GARCH (GARCH(-1)) probabilities are statistically significant, indicating the presence of volatility. The implication is that previous month's exchange rate information (ARCH) can influence the present month's Ksh exchange rate volatility with respect to the pound. Furthermore, the GARCH term is also significant, meaning that the previous month's exchange rate volatility can influence the present month's volatility.

Table 4.4 also shows that both the ARCH and GARCH terms are statistically significant, hence volatility is present. The ARCH term ($\text{RESID}(-1)^2$) indicates that the previous month's volatility information influences the current month's volatility. The GARCH term (GARCH(-1)) is also significant, showing that the previous period's volatility influences the present period's volatility.

Table 4.3: GARCH equation for the UK pound volatility

Dependent variable	UK pound	
Variable	Coefficient	Prob.
C	0.156011	0.3233
LREALPOUNDLAG1	0.968693	0.0000
Variance Equation		
C	0.009280	0.4114
RESID(-1) ²	-0.014395	0.0000
GARCH(-1)	0.872808	0.0000
LREALPOUNDLAG1	-0.001541	0.5064
LTEA	-3.33E-05	0.9707
R-squared		0.927118

Table 4.4: GARCH equation for euro volatility

Dependant variable	EU euro	
Variable	Coefficient	Prob.
C	-0.008759	0.7725
LREALEUROLAG1	1.000678	0.0000
Variance Equation		
C	0.000992	0.0000
RESID(-1)^2	-0.00712	0.0072
GARCH(-1)	1.017667	0.0000
LREALEUROLAG1	-0.000201	0.0000
R-squared	0.943684	

4.5 Bounds Testing and Analysis of Long Run Relationship

Having established the order of integration for all the variables to be either $I(1)$ or $I(0)$, the existence of a long run relationship between each export commodity, the real exchange rate as per destination, exchange rate volatility, and the host country's income was tested. Each commodity had a model containing five regressors and, therefore, the 95 per cent critical value bounds given by Pesaran *et al.* (1999) is 3.12, 4.25. For all the equations, the null hypothesis of no long run relationship is rejected because the calculated F-statistic exceeds the upper bound critical value of 4.25. Table 4.3 shows the estimated long run elasticities for the tea, horticulture and coffee equations.

The results indicate that real exchange rate appreciation affected horticultural exports positively both in the short and long run, and the effects were statistically significant. Importer's income had a positive and significant effect on horticultural exports to the EU, with a multiplier effect of 1.87 per cent. A unit increase in EU incomes would therefore lead to a 1.87 per cent change in Kenya's horticultural exports to the EU over time. On the other hand, increase in Kenya's income had a negative effect on export of horticultural products, though statistically insignificant. Exchange rate volatility was found to have a negative and statistically significant long run effect on horticultural exports, with a multiplier effect of -0.1. A unit increase in exchange rate volatility would, therefore, lead to a decrease in horticultural exports by 0.1 per cent.

Table 4.5: Bounds tests

Export commodity	Calculated F-statistic
Tea	7.32
Horticulture	19.67
Coffee	11.65

Importers income had a negative and statistically significant effect on tea exports to the UK, with a multiplier of -1.66 per cent. This result depicts negative income demand elasticity for tea exports to the UK. It could be a pointer to the fact that, in this case, the income effect outweighs the substitution effect and that with increase in incomes, there could be other commodities that are consumed as opposed to Kenyan tea. Exporter income for this equation was positive, though statistically insignificant. Real exchange rate was positive and statistically significant for tea, with a long run multiplier of 0.72. A unit change in real exchange rate would, therefore, increase exports by 0.72 per cent. This was similar to findings by Freund and Pierola (2008), who observed that export surges were associated with greater exchange rate depreciation, and further pointed out that currency depreciation could be used as an instrument for growth only in the short term, because an economy could not sustain a depreciated exchange rate indefinitely. Eichengeen and Gupta (2012) stated that exchange rate depreciation could not be used as an instrument for export growth in the long term.

Real exchange rate volatility was found to have a positive relationship with tea exports to the UK. It had a coefficient of 0.23 and a multiplier of 0.21 per cent. A unit increase in the level of volatility would, therefore, increase exports by 0.21 per cent. According to Freund and Pierola (2008), low exchange rate volatility is often associated with higher export surges.

Both importers and exporters incomes were found to be significant, though with different signs for coffee exports to the EU. Importer income had a negative coefficient with a multiplier of -7.73. In terms of elasticity of demand for Kenyan coffee exports to the EU, perhaps the income effect outweighs the substitution effect, hence the negative coefficient. Exporter income nevertheless took an expected sign with a multiplier of 6.17, indicating that a unit increase in national income would result to a 6.17 per cent increase in coffee exports to the EU. Though insignificant, real exchange rate volatility and appreciation were observed to have a negative effect on coffee exports.

Importers income was significant and negative for coffee and tea, but positive and significant for horticultural products. The coefficient for exporters income was positive for both coffee and tea, though significant for coffee, but insignificant for tea. In the case of horticulture, importers income was positive and significant.

The real exchange rate was negative and insignificant in the coffee equation, but positive and significant for both tea and horticulture. Real exchange rate volatility had a negative coefficient for both coffee and horticulture, though significant for horticulture. However, it was insignificant for coffee. The real exchange rate volatility coefficient was positive and significant for tea.

Table 4.3: Estimated long run coefficients

Variable	Coffee	Tea	Horticulture
Importer's income (Y_{jt})	-5.687*** (0.0004)	-1.483*** (0.0135)	2.138926*** (0.0059)
Exporter's income (Y_{kt})	4.5435*** (0.0001)	0.029 (0.9904)	-0.940248 (0.5786)
Real Exchange Rate (RER_t)	-0.146 (0.5516)	0.750586*** (0.0056)	0.219366*** (0.0287)
Real Exchange Rate Volatility (EV_t)	-0.0377 (0.6740)	0.2321*** (0.0189)	-0.105011*** (0.0030)

The figures in parenthesis represent standard errors

The estimated long run multipliers for each commodity were as follows:

For the coffee equation: $Y_{jt} = -7.73$; $Y_{kt} = 6.17$;

Tea equation: $Y_{jt} = -1.66$; $RER_t = 0.72$; $EV_t = 0.21$; and

Horticulture equation: $Y_{jt} = 1.87$; $Y_{kt} = -0.61$; $RER_t = 0.24$; $EV_t = -0.1$.

See equations 1 and 2 for computations.

5. Summary and Policy Recommendations

The study sought to establish how exchange rate volatility affected Kenya's key exports, namely: coffee, tea and horticulture. Bounds testing and ARDL modeling through general to specific method were applied to test for the existence of both a long and short run relationship. The null hypothesis of no long run relationship between the estimated variables was rejected for all the commodities.

Results from this study are mixed. Real exchange rate volatility was found to have a negative and significant effect on horticulture, negative and insignificant effect on coffee, and a positive and significant effect on tea exports. These findings are partly in line with Chege *et al.* (2014) and Kiptui (2008) to the extent that the study found a negative and significant long run effect of real exchange volatility on horticultural exports. The rest of the findings contradict results from the two studies. The monetary authorities should, therefore, strive to keep the exchange rates stable to ascertain predictability of profits for exporters. This can be done by monitoring exchange rate movements and adopting appropriate monetary and fiscal policy stances. In addition, the government should make efforts to establish a derivatives market in Kenya. This would ease the management of currency risk exposure on the part of producers transacting in the global market.

The country currently lacks a financial derivatives exchange, since most derivative securities are being traded over the counter by well established banking institutions. This can be done by reviewing the existing policy on the derivatives market. Moreso, the government should provide a legal and regulatory framework to ensure that public interests are protected in the proposed market. Countries such as South Africa and India are developing countries that have successfully adopted a derivatives market to protect exporters from short term exchange rate fluctuations.

Importers income has been found significant in determining the demand for certain export commodities. This study proposes that more value addition be done on commodities such as coffee and tea to ensure that there is increased consumption in their destination markets. The country also needs to diversify export destinations to reduce vulnerability as a result of a few countries consuming Kenya's exports. Further, research on the income elasticity of Kenyan exports is needed. Most studies have focused on supply-side factors such as commodity prices, GDP, among others, while little has been done on demand-side factors such as foreign incomes.

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Appendix

Appendix 1: White heteroskedasticity test for the tea equation

F-statistic	0.735661	Prob. F(10,82)		0.6889
Obs*R-squared	7.656561	Prob. Chi-Square(10)		0.6623
Scaled explained SS	5.864776	Prob. Chi-Square(10)		0.8265
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.420060	6.857391	-0.498741	0.6193
@TREND	-0.001367	0.002396	-0.570660	0.5698
LTEALAG1	-0.013611	0.031392	-0.433592	0.6657
LPOUNDEVOLATILITYLAG1	0.009572	0.025566	0.374388	0.7091
LUKGDPLAG1	-0.062455	0.155261	-0.402255	0.6885
LKENYAGDP1LAG1	0.359287	0.636278	0.564671	0.5738
LREALPOUNDLAG1	0.017872	0.069772	0.256140	0.7985
LAG1DLTEA	-0.036502	0.027632	-1.321018	0.1902
LAG1DLREALPOUND	-0.060505	0.089867	-0.673273	0.5027
DLPOUNDEVOLATILITYLAG1	0.003069	0.015558	0.197267	0.8441
LAG1DLUKGDP	-0.239511	0.612800	-0.390848	0.6969

Appendix 2: White heteroskedasticity test for the coffee equation

Heteroskedasticity Test: Breusch-Pagan-Godfrey				
F-statistic	0.292227	Prob. F(5,88)		0.9161
Obs*R-squared	1.535264	Prob. Chi-Square(5)		0.9090
Scaled explained SS	1.153759	Prob. Chi-Square(5)		0.9492
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.278491	6.278150	0.203641	0.8391
LCOFFEELAG1	0.018056	0.045001	0.401234	0.6892
LKENYAGDP1LAG1	0.082404	0.386280	0.213327	0.8316
LEUGDPLAG1	-0.172930	0.639375	-0.270467	0.7874
LAG1DLKENYAGDP1	3.761162	3.989406	0.942787	0.3484
LAG1DLEUGDP	-0.375581	1.612077	-0.232980	0.8163
R-squared	0.016333	Mean dependent var		0.123636
Adjusted R-squared	-0.039558	S.D. dependent var		0.162777
S.E. of regression	0.165965	Akaike info criterion		-0.692374
Sum squared resid	2.423916	Schwarz criterion		-0.530036
Log likelihood	38.54157	Hannan-Quinn criter.		-0.626801
F-statistic	0.292227	Durbin-Watson stat		2.099705
Prob(F-statistic)	0.916091			

Appendix 3: White heteroskedasticity test for the horticulture equation

F-statistic	0.407257	Prob. F(6,87)		0.8724
Obs*R-squared	2.568022	Prob. Chi-Square(6)		0.8608
Scaled explained SS	1.901712	Prob. Chi-Square(6)		0.9285
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.443102	1.477746	0.299850	0.7650
DLREALEUROLAG1	-0.019126	0.036922	-0.518001	0.6058
LHORTICULTURELAG1	0.019930	0.021785	0.914826	0.3628
LEUROVOLATILITYLAG1	0.003090	0.007123	0.433831	0.6655
LKENYAGDP1LAG1	-0.056308	0.105824	-0.532092	0.5960
LREALEUROLAG1	-0.001127	0.020218	-0.055765	0.9557
LEUGDPLAG1	-0.007508	0.138177	-0.054334	0.9568
R-squared	0.027319	Mean dependent var		0.026889
Adjusted R-squared	-0.039762	S.D. dependent var		0.035546
S.E. of regression	0.036245	Akaike info criterion		-3.725454
Sum squared resid	0.114295	Schwarz criterion		-3.536059
Log likelihood	182.0963	Hannan-Quinn criter.		-3.648952
F-statistic	0.407257	Durbin-Watson stat		1.754434
Prob(F-statistic)	0.872396			

Appendix 4: Breusch-Godfrey serial correlation LM Test for the coffee equation

F-statistic	0.527119	Prob. F(2,86)		0.5922
Obs*R-squared	1.138353	Prob. Chi-Square(2)		0.5660
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	11.37292	17.71792	0.641888	0.5227
LCOFFEELAG1	-0.250781	0.264471	-0.948239	0.3457
LKENYAGDP1LAG1	1.327205	1.550136	0.856186	0.3943
LEUGDPLAG1	-1.559718	2.072559	-0.752557	0.4538
LAG1DLKENYAGDP1	-2.686982	9.228180	-0.291171	0.7716
LAG1DLEUGDP	2.679777	4.431345	0.604732	0.5469
RESID(-1)	0.285251	0.283374	1.006624	0.3169
RESID(-2)	0.081492	0.128304	0.635144	0.5270
R-squared	0.012110	Mean dependent var		-2.65E-15
Adjusted R-squared	-0.068300	S.D. dependent var		0.353504
S.E. of regression	0.365377	Akaike info criterion		0.905491

Sum squared resid	11.48103	Schwarz criterion	1.121942
Log likelihood	-34.55810	Hannan-Quinn criter.	0.992922
F-statistic	0.150606	Durbin-Watson stat	1.973689
Prob (F-statistic)	0.993470		

Appendix 5: Breusch-Godfrey serial correlation LM test for the horticulture equation

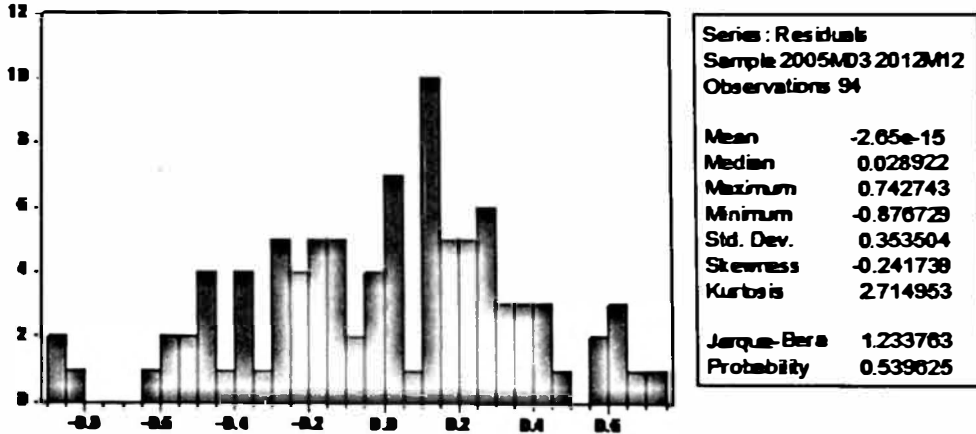
F-statistic	0.342311	Prob. F(2,85)	0.7111	
Obs*R-squared	0.751063	Prob. Chi-Square(2)	0.6869	
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.515199	7.129559	-0.072262	0.9426
DLREALEUROLAG1	-0.013489	0.176010	-0.076635	0.9391
LHORTICULTURELAG1	-0.367831	0.559929	-0.656924	0.5130
LEUROVOLATILITYLAG1	-0.034166	0.061867	-0.552250	0.5822
LKENYAGDP1LAG1	-0.182233	0.584171	-0.311951	0.7558
LREALEUROLAG1	0.081080	0.155483	0.521476	0.6034
LEUGDPLAG1	0.692747	1.270089	0.545432	0.5869
RESID(-1)	0.394749	0.588930	0.670282	0.5045
RESID(-2)	-0.045872	0.109247	-0.419893	0.6756
R-squared	0.007990	Mean dependent var	-2.61E-15	
Adjusted R-squared	-0.085376	S.D. dependent var	0.164857	
S.E. of regression	0.171750	Akaike info criterion	-0.594709	
Sum squared resid	2.507332	Schwarz criterion	-0.351202	
Log likelihood	36.95132	Hannan-Quinn criter.	-0.496350	
F-statistic	0.085578	Durbin-Watson stat	1.934332	
Prob (F-statistic)	0.999512			

Appendix 6: Breusch-Godfrey serial correlation LM test for the tea equation

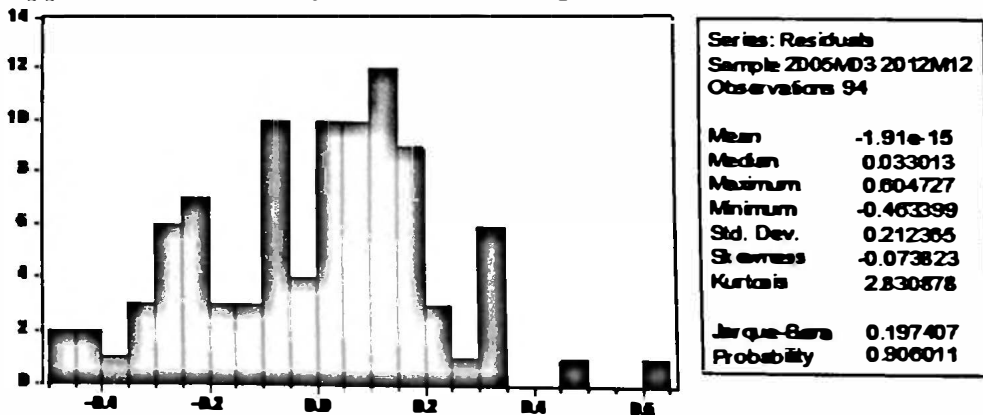
F-statistic	0.117317	Prob. F(2,86)	0.8894	
Obs*R-squared	0.255762	Prob. Chi-Square(2)	0.8800	
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LTEALAG1	-0.075704	0.348815	-0.217033	0.8287
LPOUNDVOLATILITYLAG1	-0.000880	0.030681	-0.028668	0.9772
LUKGDPLAG1	-0.078121	0.453284	-0.172344	0.8636
LTEAPRICELAG1	0.012028	0.109533	0.109809	0.9128
C	2.495332	11.88524	0.209952	0.8342

@TREND	0.000701	0.003434	0.204089	0.8388
RESID(-1)	0.065922	0.366763	0.179740	0.8578
RESID(-2)	0.077729	0.182380	0.426194	0.6710
R-squared	0.002721	Mean dependent var		-1.91E-15
Adjusted R-squared	-0.078453	S.D. dependent var		0.212365
S.E. of regression	0.220538	Akaike info criterion		-0.104228
Sum squared resid	4.182782	Schwarz criterion		0.112222
Log likelihood	12.89873	Hannan-Quinn criter.		-0.016798
F-statistic	0.033519	Durbin-Watson stat		1.930982
Prob (F-statistic)	0.999952			

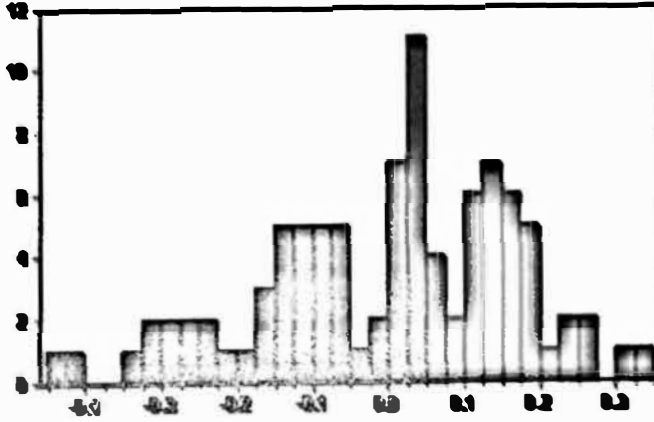
Appendix 7: Normality test for tea equation



Appendix 8: Normality test for coffee equation



Appendix 9: Normality test for horticulture equation



Series: Residuals	
Sample: 2005M03 2012M12	
Observations: 94	
Mean	-2.01e-15
Median	0.025820
Maximum	0.334775
Minimum	-0.438435
Std. Dev.	0.164857
Skewness	-0.453132
Kurtosis	2.728993
Jarque-Bera	3.504472
Probability	0.173386

