Effect of Exchange Rate Volatility on Rwanda Coffee Export between Years 2001-2016

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Available Online: 30th June, 2018

URL: http://www.journals.adrri.org/


Abstract

This paper investigates the effect of exchange rate and exchange rate volatility on the volume of exported coffee from Rwanda to major importing countries for the period of 2001 to 2016. Generalized autoregressive conditional heteroskedasticity model was used to estimate exchange rate volatility (shock) and autoregressive distributed lag approach was used to estimate the relationship between exchange rate volatility and export volume. Results from this study indicated a positive relationship between exchange rate volatility and coffee export volume in the short-run while long-run effect showed a negative relationship. Therefore, Rwandan agricultural export policies should consider the existence, degree and likely effects of exchange rate fluctuation for coffee in order to design, develop and implement trade policies regarding coffee export.

Keywords: ARDL model, Exchange rate volatility, Exports, GARCH model
INTRODUCTION

Trade is widely accepted as a major engine of economic growth (Omojimite and Akpokodje, 2010). Exports of goods and services represent the value of all goods and other market services provided to the rest of the world (World Bank, 2015). Agriculture export sector is one of the vital sectors for Rwanda regarding foreign exchange earnings. Coffee exports account for 35 percent of agricultural exports earnings and about 9 percent of total Rwanda’s goods exports (Broka et al., 2016). Theoretically, exchange rates and exchange policies have a huge bearing on the performance of the country’s exports. According to the Bank for International Settlement report, (2013) the foreign exchange market is by far the largest and most liquid financial market in the world. The foreign exchange market is primarily made of three inter-related parts; forward transaction, spot transaction and derivative contracts (Broll and Hansen-Averlant, 2010). The currency market as for other financial market can be volatile; the volatility is usually defined as the standard deviation or variance of the returns of an asset during a given period (Pilbean and Langeland, 2015).

Initially, there are two exchange rate systems; fixed and floating exchange rate. The fixed exchange rate is meant to be fixed for a given period of time. On the other side, floating exchange rate allows up and down movement of currency minute by minute (Clark et al., 2004). Floating exchange rate system brought two schools of thought; Traditional and Risk-portfolio contrasting while explaining the effect of exchange rate volatility on exports. The traditional school of thought argues that higher volatility increases risk thus depresses trade flows (Clark 1973; Baron 1976; Hooper and Kohlhagen 1978; Cote, 1994). Conversely, the risk-portfolio school maintains that higher risk presents greater opportunity for profit and increases trade. This means that an
increase in exchange rate volatility leads to raising of the export volumes (Broll and Eckwert 1999, Dellas and Zilberfarb 1993; De Grauwe 1988).

In fact, the exchange rate volatility is an important factor in explaining the worldwide trade pattern and creates risk in macroeconomic policy formulation, investment decisions and international trade flows (Musonda, 2008). The Exchange rate fluctuation is mainly a concern for firms that are linked to international markets; creation of gains or losses to farmers and exporters (Raddatz, 2008). These unexpected losses caused by exchange rate fluctuation result in decreased production, affected volumes of trade which further, affects international price competitiveness of exports leading to resource reallocations, which has a negative impact on economic efficiency (Pugel, 2007). Hence, domestic agriculture is capable of contributing beneficially to the balance of overseas payments either by increasing the country’s export earnings or by expanding the production of substitutes of agricultural import.

Export of agricultural products is one of the significant sources of income in the Rwandan economy. Coffee is among the main source of agricultural exports earnings. Efforts have been made to modernize and boost production in that sector in terms of quality and the quantity. However, over the last 16 years, the share of exports to the GDP has been fluctuating considerably and has not been determined if the cause is exchange rate volatility. Moreover, the role of exchange rate volatility on the export of tea and coffee in Rwanda remains unknown in empirical literature. Therefore, this study was conducted to generate baseline information on the effect of exchange rate and exchange rate volatility on coffee export in Rwanda. With the aim of contributing towards the improved performances of shares of coffee exports to GDP through better exchange rate policy, in Rwanda.
The study aimed at testing the following hypothesis: There is no significant effect of exchange rate fluctuations on the volume of exported coffee from Rwanda to major importing countries from the year 2001 to 2016. There is no significant effect of exchange rate on the volume of exported coffee and tea from Rwanda to major importing countries from the year 2001 to 2016. Exports are the key component for the achievement of the Rwandan economic goals as envisioned in its Economic Development and Poverty Reduction Strategy (EDPRS), and Vision 2020. The Rwandan economic development blueprint aims at increasing the volume of trade exports by 15% per annum by 2020. This is seen as imperative in the achievement of Vision 2020 whereby Rwanda expects to have an improved balance of trade. Agriculture, tourism, and mining sectors are the priority sectors for Rwandan five-year National Export Strategy (NES). Particularly tea, coffee and the non-traditional horticultural products are central to the realization of the national export strategy (MINICOM, 2011).

**METHODOLOGY**

**Data**

The study used secondary monthly time series data on bilateral exports and real effective exchange rates from January 2001 to December 2016 for coffee. This period was chosen because of the availability of reliable data seven years after genocide which paralyzed the Rwandan economy in all sectors. Time series data on real exchange rates and coffee export volume were obtained from National Bank of Rwanda (NBR), National Institute of Statistic of Rwanda (NISR), National Agriculture Export Development Board (NAEB), Ministry of Agriculture and Animal Resources (MINAGRI), Food Agricultural Organization Statistics (FAOSTAT) and the World Development Indicators (WDI) of the World Bank (WB).
Analytical framework (Models)

Exploration of the relationship between Rwandese exports and the real exchange rates as well as between exports and exchange variability requires examination of integration properties of the data. Importantly, conducting co-integration analysis and Granger causality tests requires fitting of error correction model. Error correction model is based on the assumption that there are expectations about the real exchange rate series which follows an ARIMA process. In addition, an important assumption is made where the conditional variance is specified as a GARCH process. These can be specified in equation 1 through 4 as follows:

\[
A\phi_m(L)DLX_t = \gamma_0 + A\phi_m(L)\varepsilon_{1,t} \quad (1)
\]

\[
\varepsilon_{1,t} = Z_t \sqrt{h_t} \quad (2)
\]

\[
Z_t \sim N(0,1) \quad (3)
\]

\[
h_t = W_0 + \sum_{j=0}^{q} \alpha_j \varepsilon_{1,t-j}^2 + \sum_{k=1}^{p} \beta_k h_{t-k} \quad (4)
\]

\(DLX_t\) is the first difference in the natural logarithm of the real exchange rate with respect to the previous period. It represents the percentage fluctuations in the monthly real exchange rates. The residuals, \(\varepsilon_{1,t}\), in equation (1) are normal and independent and identically distributed, \(Z_t\), and \(h_t\) is the model’s conditional variance. The GARCH model, as specified in equation (4), was used to examine the dynamic conditional exchange rate volatility. The GARCH model allows \(h_t\) to vary over time. The \(h_t\) is modelled as a function of the lagged squared residuals \(\varepsilon_{t-k}^2\) as well as the conditional variance \(h_{t-k}^i\). The imposed restrictions for this model are:
These conditions are parameters that are imposed in such a way that they strictly ensure positive conditional variance. The value of the summation of the parameters in equation (4) has to less than one (1) to satisfy the necessary as well as the sufficient conditions of covariance of stationarity. The summation of the parameters may be interpreted as a measure of the persistence of variance. The first difference in the real exchange rate natural logarithms as specified in equation (1) is then used to derive the successive periods’ (DLRX\textsubscript{t} for \( k2 \)-period-ahead and \( h_{t,k3}^e \) for \( k3 \)-period-ahead) changes in the expectations of real exchange rate.

\[
DLRX_{t}^e = \gamma_0 \sum_{i=0}^{k-1} \phi_i^{j} + \phi_i^{d} DLRX_{t-k} \tag{5}
\]

\[
h_{t}^e = w_0 \sum_{i=0}^{k-1} \beta_i + \alpha_i k_{i}^{e} \varepsilon_{1,t-k} + \beta_i^{e} h_{t-k} \tag{6}
\]

The DLRX\textsubscript{t} series is then undifferentiated back to exchange rate levels \( RX_{t-k2}^e \), which indicates the expected level of exchange rate while \( h_{t,k3}^e \) reflects exchange rate volatility. The expected values are regressors in the model as specified in equation (7). According to Kenen and Rodrik (1986), DeGrauwe (1988), Pozo (1992) and McKenzie (1999), there exists a long-run relationship between the volume of a countries exports and the level of economic activity of the importing country, real exchange rate as well as the measure of exchange rate risk. Holding this assumption true, the reduced form of the error correlation model was specified as:

\[
W_0 > 0; \beta_k \geq 0, \forall k \quad \text{and} \quad \alpha_j \geq 0, \forall j
\]
\[ \ln Q_{i,t} = \delta + \sum_{k=1}^{a} \delta_{1,k1} \ln (IP_{t-k1}) + \sum_{k=2}^{b} \delta_{2,k2} \ln (RX_{t-k2}) + \sum_{k=3}^{c} \delta_{3,k3} \ln (h_{t-k3}) + \sum_{k=4}^{d} \delta_{4,k4} S_{t-k4} + \sum_{k=5}^{c} \delta_{5,k5} \ln (Q_{t-k5}) + \varepsilon_{2i,t} \]  

where \( Q_{i,t} \) is Rwandese coffee export to its export partner in time \( t \), \( IP_{t-k1} \) is the monthly industrial production of export partner. The industrial production was used as a proxy for the exogenous component in period \( t-k1 \). \( RX_{t-k2} \) is the expected rate that is predicted for traders time \( t \) during \( t-k2 \) period as generated in equation (5), \( h_{t-k3} \) is the analogous estimates of the expected monthly exchange rate volatility as predicted by traders and \( k1, k2 \) and \( k3 \) are optimal lags and leads that were identified using Hendry non-standard method.

The quarterly dummy variable, \( D_{k4,i} \), was introduced to control the seasonality effect that is inherent in export plots. \( Q_{t-k5} \) is the lagged export volume that was included in the model specification so as to allow for an estimable lag length of the autoregressive persistence in export volumes. The equation error term, \( \varepsilon_{2i,t} \), is assumed to hold Gauss-Markov properties. Variables in equation (7) are natural log transformation except \( D_{k4,i} \), thus capturing elasticity effect.

Time series data is inherently non-stationary and unpredictable. Therefore, the regression estimates obtained from the analysis of time series data may be misleading. Therefore, performing time series stationarity test is important. According to Gujarati and Porter (2009), time series data need to be transformed to stationary data upon performing of stationarity test in order to avoid reporting spurious results. The Augmented Dickey-Fuller Test (ADF) and the Phillippe Perron (PP) test were used as stationarity tests. The series are differentiated and repeatedly lagged until it becomes stationary. The time series are tested for co-integration when they are integrated in the
This means that $y_t$ and $x_t$ in the regression equation (8) does not drift too far from each other overtime.

$$y_t = \beta x_t + e_t$$  \hspace{1cm} (8)

This indicates the existence of a long-run equilibrium relationship between the time series variables, that is, the series in equation (7) move together over time or I (0). Any two series which are individually I (1) yield a linear combination which is I (0) because by subtracting the regressor from the regressand, the stochastic trend which makes the series individually I (1) was eliminated hence their linear combination become stationary. On the other hand, if $y_t$ and $x_t$ are not co-integrated, that is, $y_t - \beta x_t = e_t$ is also I(1), they can drift from each other overtime. This implies that there exists no long-run equilibrium relationship between them hence regressing $y_t$ on $x_t$ yields spurious results as indicated by Maddala (1992).

The ARDL bounds testing procedure was used to test for the co-integration of variables in equation (7). The procedure was critical since variables were not integrated of the same order. This involved modelling equation (7) as an ARDL model. The general ARDL representation was specified as follows:

$$\Delta \ln Q_{t,k} = \delta + \sum_{k=1}^{a} \delta_{1,k,1} \Delta \ln (P_{t-k}) + \sum_{k=2}^{b} \delta_{2,k,2} \Delta \ln \left( RX_{t-k}^{e} \right) + \sum_{k=3}^{c} \delta_{3,k,3} \Delta \ln \left( h_{t-k}^{e} \right) + \sum_{k=4}^{d} \delta_{4,k,4} \Delta S_{k,4,t} + \sum_{k=5}^{e} \delta_{5,k,5} \Delta Q_{t-k,5}^{e} + \beta_{1,k,1} \ln (P_{t-k}) + \beta_{2,k,2} \ln (RX_{t-k}^{e}) + \beta_{3,k,3} \ln (h_{t-k}^{e}) + \beta_{5,k,5} \ln (Q_{t-k,5}^{e}) + e_{2,t}$$  \hspace{1cm} (9)

The terms that have the gammas are the short-run dynamics while the betas represent long-run estimates. F-test was implemented to test for co-integration of the variables. The F-test tested the null hypothesis that betas are jointly equal to zero ( $\beta_{1,k,1} = \beta_{2,k,2} = \beta_{3,k,3} = \beta_{5,k,5} = 0$). The Pesaran et al. (2001) provide lower and upper bound
critical F-values and were scrutinized for co-integration. The null co-integration hypothesis is not rejected when the computed lower bound F value is less than the critical F value but is rejected when the computed upper bound F value exceeds the critical F value or otherwise the F test is inconclusive.

Maddala (1992) argued, according to the Granger representation theorem, that when there is no co-integration among variables, the Error Correction Model (ECM) can be used to describe the short-run dynamics of the variables. This implies that the ECM is estimated when the long-run linear combination of residuals of non-stationary 1(1) series are inherently stationary (Okoruwa, 2003). Equation (10) specifies the ECM.

$$\Delta \ln Q_{i,t} = \delta + \sum_{k=1}^{a} \delta_{1,k} \Delta \ln (IP_{t-k}) + \sum_{k=2}^{b} \delta_{2,k} \Delta \ln (RX_{i,t-k}^e) + \sum_{k=3}^{c} \delta_{3,k} \Delta \ln \left( h_{i,t-k}^e \right) +$$

$$\sum_{k=4}^{d} \delta_{4,k} \Delta S_{k,t} + \sum_{k=5}^{e} \delta_{5,k} \Delta \ln \left( Q_{i,t-k}^e \right) + \pi ECM_{t-1} + \varepsilon_{2,t}$$

Equation (10) presents a description of the variation in $\ln Q_{i,t}$ around its long-run trend in terms of a set of I (0) exogenous factors. The impulse response of the predicted outcome (monthly coffee or tea exports) to the predictor variables in a dynamic setup is analysed using the ECM. The residual in equation (10) indicates the speed of monthly coffee exports adjustment towards the long-run equilibrium position. It shows the percentage by which any deviations of the dependent variable are corrected within a particular time frame, one month in this case because the study used monthly data (Mwansakilwa, 2013). The negative error term implies that the predicted variable has to fall in the next period for equilibrium to be restored. On the other hand, when the residual is positive, the predicted variable has to rise in the next period for equilibrium to be restored.
RESULTS AND DISCUSSIONS

Estimated results and diagnostic test on exchange rate models

It is important to perform stationarity test of times series data before econometric estimation. Testing for stationarity is critical in avoiding the possibility of making inappropriate, erroneous or misleading inferences. The Dickey-Fuller test was conducted and it was established that the exchange rate was weakly stationary at level so it was differenced once. However, before the next step of running a GARCH model, two conditions were tested. The first condition was to check if there were clustering volatility and arch effects. Ordinal Least Square (OLS) regression was run and the residues were predicted. Then the residues were graphed against the years (Figure 1). The graph shows that there were clustering volatilities; that is, periods of high volatilities followed one another and also periods of low volatilities behaved in a similar manner.

*\( m \): monthly series (January to December)
Figure 1: Clustering effects

The second condition was to test the presence of arch effects. Ordinal Least Square (OLS) was run and the null hypothesis tested. The null hypothesis was thus rejected, which means that there are arch effects, at 1 percent significant level.

Unit root test

It is necessary in time series analysis to perform unit root test of the variables that are used in estimating relationship between dependent and independent variables. Trade flows and exchange rate volatility are typically, in many cases, non-stationary and stationary respectively. This means that the currency risk does not necessarily determine trade volumes (Barret, 2007). Although there are several documented unit root test, the ADF (1979) and PP (1988) tests are commonly used. The study used the two tests to check the robustness of the estimated relationships between the exports and the independent variable in order to ensure that the inferences derived from the analysis were not influenced by test procedures.

The ADF and PP tests are parametric and non-parametric respectively. This makes the PP test a more powerful stationarity test for small samples compared to ADF test since it un-paramatizes the ADF test. Despite the ADF test being commonly used, it requires homoscedastic as well as uncorrelated errors (Gujarati and Porter, 2009). On the other hand, the PP test generalizes the ADF procedure by relaxing the ADF time series assumptions. However, two tests produce similar test statistics in most empirical evaluations of larger samples. The unit root test results of the variables used in the econometric analysis are provided in Table 1. All variables were found to be stationary at the first difference but some were not stationary at level.
Table 1: Unit root test

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADF</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>First difference</td>
</tr>
<tr>
<td>Industrial production</td>
<td>-2.270</td>
<td>-20.707&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Coffee export</td>
<td>-9.381&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-19.371&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Exchange rate volatility</td>
<td>-5.050&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-18.097&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Real effective exchange rate</td>
<td>-2.370</td>
<td>-7.075&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Note: <sup>c</sup> Denotes rejection of the null hypothesis of a unit root at 5 percent level of significance (MacKinnon, 1991).

Meaningful relationship between the dependent variable and the explanatory variables is drawn when the variables are stationary or co-integrated. Stationarity or the order of integration of the variables is provided by the unit root tests. The ADF and PP test were performed at both variable level and at their respective first differences. The variables that were tested included coffee and tea exports, industrial production, the real effective exchange rate as well as the exchange rate volatility for the 2001-2016 period. Testing for the stationarity of the variables is based on the null hypothesis that there is a time series unit root (non-stationary) and the corresponding alternative hypothesis is that the time series under consideration is stationary (Greene, 2012). When the ADF and PP computed values exceed their respective absolute values at 5% significance level and are at -3.5 at level and first difference, then the null hypothesis is rejected (Enders, 2010).

Results in Table 1 indicate that the computed ADF and PP test statistics for coffee export volumes and the exchange rate volatility exceed the absolute critical values at 5% significance level. This implies that the variables are stationary at level. However, the computed values for ADF and PP tests for industrial production and real effective
exchange rate are less than the absolute critical values. This implies that they are not stationary at level and the variables are integrated. Thus, the variables were integrated of order one process and found to be stationary. This means that all the variables used in the model were stationary at the first difference.

Pesaran et al. (2001) proposed that the Auto Regressive Distributed Lagged (ARDL) bounds test is a suitable and amiable method for testing co-integration. It provides co-integration estimates irrespective of how the variables are integrated. The other advantage of ARDL is the simultaneity of providing both short-run and long-run dynamic estimates. The ARDL approach to co-integration has upper and lower bounds. ARDL is based on the null hypothesis of no co-integration among the variables. If the computed F statistic exceeds the F critical, then the null hypothesis is rejected. However, the null hypothesis is not rejected if the calculated F value is less than F critical at the lower bound. On the other hand, the ARDL test procedure for co-integration is inconclusive when the computed F values lies between the two bounds. Trace statistics, Engle and Granger residual test and the Eigen value tests are used to test for co-integration in circumstances when the ARDL lies between the lower and upper bounds.

Coffee export function

Co-integration among variables that affect coffee exports

Table 2 presents co-integration results of factors that affect coffee exports. The results were generated from bounds test approach. The calculated F statistic exceeds the F-critical at 10, 5, 2.5 and 1 percent respectively. Thus, there exists a long-run relationship among the variables.
Table 2: F-Bound Test for coffee export estimate function

<table>
<thead>
<tr>
<th>Test Statistic</th>
<th>Value</th>
<th>Significance level</th>
<th>I(0)</th>
<th>I(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-Statistic</td>
<td>10.27</td>
<td>10%</td>
<td>2.97</td>
<td>3.74</td>
</tr>
<tr>
<td>K</td>
<td>3</td>
<td>5%</td>
<td>3.38</td>
<td>4.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.50%</td>
<td>3.8</td>
<td>4.68</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1%</td>
<td>4.3</td>
<td>5.23</td>
</tr>
</tbody>
</table>

A test of the residuals shows that they are stationary. This indicates that the variables are co-integrated (Table 3). Section 3.3.2 presents the dynamic short-run and long-run relationship between coffee exports and the explanatory variables.

Table 3: Unit root for coffee export estimate function

<table>
<thead>
<tr>
<th></th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey Fuller test statistic</td>
<td>-12.2769</td>
<td>0.0000</td>
</tr>
<tr>
<td>Test critical values:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1% level</td>
<td>-3.4712</td>
</tr>
<tr>
<td></td>
<td>5% level</td>
<td>-2.8794</td>
</tr>
<tr>
<td></td>
<td>10% level</td>
<td>-2.5764</td>
</tr>
</tbody>
</table>

Note: *Mackinnon (1991) one-sided p-values

Estimation of short-run and long-run relationships of coffee export function

The ARDL (22, 22, 22, 15), where (22, 22, 22, 15) are the number of lags of CEXP, IP, REERF and HtF respectively, was used to estimate factors that affect coffee exports. The Akaike Information Criterion was performed to determine the lag structure of the ARDL model. The trend variable was also included in the model. Factors that affect coffee exports and the corresponding co-integration equation are shown in Tables 4 and 5. Table 4 presents the long-run coefficient estimates for the export function.
The result indicates that industrial production of the importing country had a significant and positive long-run influence on coffee export volumes. A one percent increase in the income of the trading partner resulted in 26.94 percent increase in the volume of coffee exports. This may be attributed to the moderate adjustment in importation of coffee when incomes increase such that an increase in incomes may still increase imports. On the other hand, long-run increase in the trading partners’ incomes may direct resources towards other highly productive products and reduce domestic coffee production, thereby increasing the amount of coffee imports from Rwanda.

The finding is consistent with Mwansakilwa et al. (2013) who found a positive and significant association between Zambian flower export volumes and the industrial production of Germany, the Netherlands and the United Kingdom. Similar results were reported by Sane (2008) in a study that investigated the effect of the other countries real incomes on the United States’ agricultural exports. On the other hand, Anagaw and Demissie (2012) found a positive but insignificant impact of an increase in the trading partner’s real gross domestic product on Ethiopian exports. However, the result of this study contradict findings of Idisardi (2010) who found a negative effect of the real income of South Africa’s trading partner on its sunflower seed, weed and cereal pellet exports.

Table 4: Long-run coefficients for coffee export function

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-value</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP</td>
<td>26.9389***</td>
<td>3.4605</td>
<td>7.7846</td>
<td>0.0000</td>
</tr>
<tr>
<td>EXRATEF</td>
<td>7.4052</td>
<td>5.6321</td>
<td>1.3148</td>
<td>0.1942</td>
</tr>
<tr>
<td>HtF</td>
<td>-44.4491***</td>
<td>1.5924</td>
<td>-2.7939</td>
<td>0.0072</td>
</tr>
<tr>
<td>@Trend</td>
<td>-0.0555***</td>
<td>0.0059</td>
<td>-9.3247</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Note: *** means significant at 1 percent.
Exchange rate volatility was negative and significantly associated with the long-run elasticity of Rwandese coffee exports. A one percentage increase in exchange rate volatility resulted in a 44.45 percent long-run decrease in coffee export volumes. Davis et al. (2014) reported similar results by indicating that the long-run exchange rate volatility was negative and significantly associated with broiler trade. In contrast to this study, Obi et al. (2013) and Goudarzi et al. (2012) found that exchange rate volatility was positively associated with agricultural export volumes. Similarly, Kohansal et al. (2013) also indicated that exchange rate volatility had a long-term positive effect on medicinal plant exports. However, Fedoseeva (2016) noted that the volumes of exports were less affected, compared to export values, by exchange rate volatility.

Table 5 presents the short-run coefficients estimates from the coffee export function. The results are consistent with economic theory and have the correct signs. The previous month’s export volumes were positive and significantly associated with the current level of coffee export volumes. The coefficient of the lagged exports implies that one percentage increase in the previous month’s coffee export volume leads to an augmentation in the current coffee exports volume by 5.14 to 0.28 percent respecting one to twenty-one previous months in short-run. This may be due to previous performance on the international market. If a nation exported more in the previous months and gained profit, then it increases the volume of exports in the current period.

The real income or industrial production of the importing country positively and significantly influenced the volume of coffee exports in the short-run. A one percent increase in the importing country’s real income increased the short-run coffee export volumes by 38.47. The finding concurs with results by Ragoobur and Emamdy (2011) who established a positive effect of importing country’s real income on Mauritius agricultural exports in the short-run. Goudarzi et al. (2012) also found a positive and
significant relationship between Iranian pistachio export volumes and importing
country’s real income.

Table 5: Short-run coefficients for coffee export function

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std.error</th>
<th>t-Value</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-4921.3950***</td>
<td>662.3719</td>
<td>-7.4299</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(CEXP(-1))</td>
<td>5.1422***</td>
<td>0.8029</td>
<td>6.4044</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(IP)</td>
<td>38.4758*</td>
<td>18.1127</td>
<td>2.1242</td>
<td>0.0383</td>
</tr>
<tr>
<td>D(XRATEF)</td>
<td>42.2534</td>
<td>80.7635</td>
<td>0.5232</td>
<td>0.6030</td>
</tr>
<tr>
<td>D(HtF)</td>
<td>-3.8183</td>
<td>5.8211</td>
<td>-0.6559</td>
<td>0.5147</td>
</tr>
<tr>
<td>X1</td>
<td>-1.1727</td>
<td>2.4842</td>
<td>-0.4720</td>
<td>0.6388</td>
</tr>
<tr>
<td>X2</td>
<td>0.5893</td>
<td>2.3618</td>
<td>0.2495</td>
<td>0.8039</td>
</tr>
<tr>
<td>X3</td>
<td>4.7946*</td>
<td>2.6735</td>
<td>1.7934</td>
<td>0.0786</td>
</tr>
<tr>
<td>CointEq (-1)*</td>
<td>-6.3960***</td>
<td>0.8607</td>
<td>-7.4309</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

R-squared 0.7405
Prob (F-statistic) 0.0000
Breusch-Godfrey LM Test (Prob>. Chi-Square) 0.2616
Breusch-Pagan-Godfrey (Prob>. Chi-Square) 0.1842
Ramsey RESET Test (Prob F) 0.0000
Jarque-Bera (Prob) 0.1411

Notes: ***, **, * significant at 1%, 5% and 10% levels respectively

The previous period (months) exchange rate fluctuation (shock) was positive and
statistically significant in the short-run, which means it had a significant short-run
influence on coffee export volumes. In other words, 1% increase in exchange rate shock
in the previous month increases coffee exports; that is, an increase in the previous
month of shocks increases the current coffee exports volume by 5.14 percent.
There are at least two reasons to explain the Rwandan coffee export sensitivity to exchange rate fluctuation. First, Rwanda’s agricultural export crops such as coffee are relatively import intensive. That is, production of Rwanda’s exportable agricultural commodities or products is highly dependent on a considerable importation of inputs such as pesticides and fertilizers. Exchange rate shocks create uncertainty due to heavy dependence on imported intermediate inputs in the agricultural sub-sector. In addition, the dependency on imported intermediate inputs causes cost and input volatility, resulting in export revenue fluctuation. The smallholder nature of the Rwandese agriculture and agribusinesses also undermines coffee export volumes.

The seasonality of coffee exports positively and significantly influenced the Rwandan coffee exports at 10% significance level. Season three had a positive short-run effect on the current coffee export. This can be cautiously interpreted to mean that the occurrence of season three is likely to increase coffee export volumes by 4.79%. The negative and significant error correction term affirms that the variables are co-integrated. The error correction term coefficient implies that 63.96% of the export disequilibrium is corrected monthly because the frequency of the data is monthly. Also, the large and significant error correction term suggests a high speed of adjustment towards the long-run equilibrium. The reported R-squared suggests that the variables in the estimated model explain 74% of the variation in coffee exports.

**Post-estimation diagnostic tests for factors affecting coffee exports**

Tables 5 presents results from autocorrelation test, the Breusch-Pagan–Godfrey test for heteroscedasticity, Jarque-Bera normality test and the Ramsey-Reset test for model specification. The computed probability value was 0.2616, implying that the null hypothesis that the model is autocorrelation free was upheld. The Breusch-Pagan–Godfrey test probability value was 0.1842 (Table 5). The result implies that the
The homoscedasticity hypothesis is not rejected. The normality assumption of the distribution was tested using the Jarque-Bera test. Jarque-Bera probability value was 0.1411, suggesting that the residuals were normally distributed. The result from the Ramsey-Reset test suggested that the model was properly specified; that is, neither relevant variables were omitted, nor irrelevant variables were included in the model.

The Cumulative Sum of Recursive Residuals (CUSUM) (Figure 2) and Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) (Figure 3) were also used to confirm the stability of the coefficients with the null hypothesis that the coefficients are stable against the alternative hypothesis that the coefficients are not stable. The plots show that the coefficients are stable as the recursive residuals are significant at 5% significance level. Thus, the null hypothesis was not rejected, suggesting that the estimated coefficients were stable and consistent.

![CUSUM and 5% Significance Plot](image)

**Figure 2:** Cumulative sum of recursive residuals for coffee export function
CONCLUSIONS AND POLICY RECOMMENDATIONS

There was an optimistic effect between exchange rate fluctuations with respect to export volumes of coffee in the previous months. In the long-run, exchange rate shock reduced the volumes of coffee exports. The results suggest the need to review the monetary policy in order to fix the issue of exchange rate volatility. The currency stabilization can be the answer by using discretionary monetary policy. This policy will allow the policy makers to react on time according to the existence, degree and likely effects of exchange rate fluctuation for each commodity while implementing trade policies. As such, trade policy will be geared towards overall macroeconomic stability supported by a competitive exchange rate as well as structural reforms that will contribute to increased productivity and the enhancement of international competitiveness.

Figure 3: Cumulative sum of square of recursive residuals for coffee export function
Further research is needed for each and every agricultural export commodity and other sectors so that from the findings the policy makers can design, develop and implement the right and competitive trade policy. Despite the importance of understanding the effect of exchange rate volatility of agricultural export volumes, there is also the need to understand its effect on Rwandese imports. The study suggests that future research needs to explore and evaluate the sources of exchange rate volatility and the extent to which these sources determine its effect on exports. Lastly, future studies should go beyond focusing only on the responsiveness of agricultural exports to exchange rate fluctuation and give attention to the international competitiveness of the Rwandan agricultural exports.

Acknowledgements

I would like to acknowledge the African Economic Research Consortium (AERC) through the Collaborative Masters of Science in Agricultural and Applied Economics (CMAAE) secretariat for the scholarship they offered me to pursue Master degree in Agricultural and Applied Economics in Egerton University and University of Pretoria and also all the financial support including the school fees, research fund and living allowances which enabled me to complete the program. I would also like to acknowledge NAEB, BNR, NISR, WB and MINAGRI for their provision of the data used in this research. In a special way, I am indebted to thank my university supervisors, Dr. Oscar Ayuya Ingasia and Prof. Job Lagat for their tireless efforts and invaluable input into this research.
REFERENCES


