# RESPONSE OF AGRICULTURAL EXPORTS TO FLUCTUATION IN EXCHANGE RATE IN RWANDA: CASE OF COFFEE AND TEA BETWEEN YEARS 2001-2016

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**A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for the Award of Master of Science Degree in Agricultural and Applied Economics of Egerton University**

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## DECLARATION AND RECOMMENDATION

### Declaration

I hereby declare that this thesis is my original work and has not been presented in this or any other university for the award of any degree.

Signature …………………………… Date ………......../………/ 2018

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### Recommendation

This thesis has been submitted to the Graduate School of Egerton University with our recommwndation as the university supervisors.

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# DEDICATION

To my beloved wife Mukakayigi Delphine, my beloved daughter Muhire Iriza Audrey and my lecturers.

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## ABSTRACT

The agriculture sector is the backbone of Rwandan economy with tea and coffee as the major source of export earnings. However, between years 2001 and 2016, the share of agriculture exports to the GDP has been fluctuating considerably, and yet it has not been established if this is due to exchange rate volatility. The overall effects of these fluctuations are not obvious and empirical literature is not conclusive on the overall impact of real exchange rate fluctuations on agriculture exports, hence the need to carry out the current study. The general objective of this study was to contribute towards the improved performance of share export to GDP through better exchange rate policy, with reference to coffee and tea exports in Rwanda from 2001 to 2016. Monthly time series data for 16 years from 2001 to 2016 were used and analyzed by STATA and E-views. Descriptive statistics along with trend analysis were used. GARCH model was used to determine exchange rate volatility and ARDL was used to estimate the main model. Results indicated that there was a reduction in quantities of coffee exported by 0.5% per month while tea had a steady growth rate of 0.3% per month on average. A positive relationship between exchange rate volatility and coffee prices was observed in the long-run where the coefficient was 1.5. There was a negative relationship between exchange rate volatility and prices of tea in the short-run with -0.3 as the coefficient. In the long-run, a negative effect between the shock and volumes of coffee exported was exhibited, and the coefficient was -44.5 statistically significant at 1%. It The study recommends that policymakers need to consider the existence, degree and likely effects of exchange rate volatility for each product while designing, developing and implementing trade policies. To boost competitiveness of tea and coffee, firms need to diversify the range of products and aggressively search for niche markets. This will lead to international trade development, job creation, poverty reduction and to a higher rate of economic growth in Rwanda.

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| | |
|---|---|
| **ADF** | Augmented Dickey-Fuller |
| **AERC** | African Economic Research Consortium |
| **AIC** | Akaike Information Criterion |
| **AR** | Autoregressive |
| **ARCH** | Autoregressive Conditional Heteroskedastic |
| **ARDL** | Autoregressive Distributed Lag |
| **ARIMA** | Autoregressive and Integrated Moving |
| **ARMA** | Autoregressive Moving Average |
| **BIS** | Bank for International Settlements |
| **BNR** | National Bank of Rwanda |
| **CEXP** | Coffee Export |
| **CMAAE** | Collaborative Masters in Agriculture and Applied Economics |
| **CP** | Coffee Price |
| **CPI** | Consumer Price Index |
| **CTC** | crushing-tearing-curling |
| **CUSUM** | Cumulative Sum of Recursive Residuals |
| **CUSUMSQ** | Cumulative Sum of Squares of Recursive Residuals |
| **DC** | District of Colombia |
| **DRC** | Democratic Republic of Congo |
| **EAC** | East Africa Community |
| **ECM** | Error Correction Model |
| **EDPRS** | Economic Development and Poverty Reduction Strategy |
| **FAOSTAT** | Food and Agriculture Organization Statistics |
| **FOB** | Ferry on Board |
| **GARCH** | Generalized Autoregressive Conditional Heteroskedastic |
| **GARCH-M** | Multivariate GARCH |
| **GDP** | Gross Domestic Product |
| **GJR-GARCH** | Glosten, Jayannathan and Runkle GARCH |
| **GNP** | Gross National Product |
| **IP** | Industrial Production |
| **ISO** | International Organization for Standardization |
| **JB** | Jarque-Bera |

| | |
|---|---|
| **LLH** | Log Likelihood |
| **LM** | Lagrange Multiplier |
| **LR** | Likelihood Ratio |
| **MA** | Moving Average |
| **MDEs** | Medium and Developed Exporters |
| **MINAGRI** | Ministry of Agriculture |
| **MINECOFIN** | Ministry of Finance and Economic Planning |
| **MINICOM** | Ministry of Commerce |
| **MPC** | Monetary Policy Committee |
| **MT** | Metric Ton |
| **NAEB** | National Agriculture Export Development Board |
| **NBR** | National Bank of Rwanda |
| **NCS** | National Coffee Strategy |
| **NEER** | Nominal Effective Exchange Rate |
| **NES** | National Export Strategy |
| **NISR** | National Institute of Statistics |
| **OCIR THE** | Rwanda Tea Authority |
| **OLS** | Ordinal Least Square |
| **PP** | Phillips Perron |
| **REER** | Real Effective Exchange Rate |
| **REERF** | Real Effective Exchange Rate Foacast |
| **REMA** | Rwanda Environment Management Authority |
| **RoR** | Republic of Rwanda |
| **Rwf** | Rwandan Francs |
| **TEXP** | Tea Export |
| **TP** | Tea Price |
| **UNCTAD** | United Nations Conference on Trade and Development |
| **UNDAP** | United Nations Development Assistance Plan |
| **USA** | United State of America |
| **USD** | United State of America Dollar |
| **UTZ** | Universal Trade Zone |
| **WB** | World Bank |
| **WDI** | World Development Indicators |

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background information

Rwanda is a small, landlocked, agriculture-based country of 26,338 km$^2$. With 12 million inhabitants, Rwanda is one of the ten most densely populated countries in the world (MINAGRI 2015). Regardless of efforts to expand the economy, Rwanda stays an economy deeply dependent on agriculture regarding employment opportunities (UNDAP, 2013). During the last decade, agriculture contributed more than 30% of the GDP and employed over 70% of the population (NISR, 2015). During the Economic Development and Poverty Reduction Strategy one (EDPRS I) from 2008 to 2012, the contribution of agriculture to poverty reduction, food security, and economic development was significant (Tom, 2015).

The government has envisaged agriculture sector to have an annual average growth of 8.5% over the course of EDPRS II (2012-2017) (NISR, 2015). Agriculture in Rwanda is dominated by small-scale, subsistence farming under traditional agricultural practices and rain-fed agriculture (Broka *et al*., 2016). Cassava, maize, Irish potatoes, sweet potatoes, plantain, beans, rice, milk, and beef are agricultural commodities that jointly make up the top 80 percent of the value of agricultural production including coffee and tea which are important export crops (Broka *et al.*,2016).

Coffee was introduced in Rwanda in 1904 by German missionaries (NAEB, 2011). Around 1930, it was a key driver of the economy, and the Belgian colonial government made it obligatory for farmers to grow coffee but at the same time controlled prices and charged high export taxes. The consequence of this was that the farmers gained very little from their coffee. (Nzeyimana *et al*., 2013).

The most important change was the crisis of the world coffee price drop in 1990's, which was followed by the 1994 genocide in Rwanda. These two incidents took a huge toll on Rwandan coffee industry. The year 2000 was the time to rebuild the sector whose cleaning and processing infrastructure was completely devastated . It took about ten years for the industry to begin to recover, and now there is a National Coffee Strategy (NCS) to further recovery , improve and expand the industry. Farmers and their families now benefit from higher and more stable prices (MINAGRI, 2012).

Tea was introduced in Rwanda after coffee in 1952 six years before independence. Tea is grown in areas endowed with favorable natural conditions of high altitude, varying from 1500 to 3000 meters above sea level and well-distributed rainfall. Given these conditions; production of tea in Rwanda goes on all year round. With some of the best clones grown and using efficient and diligent plucking, Rwanda produces some of the brightest, briskiest, and most aromatic tea in the world (MINAGRI, 2013).

Rwandan tea is sold through auction and to private buyers. About 80 % of the tea is sold through Mombasa auction (the second biggest auction center in the world) thus giving Rwanda tea a broader scope of exposure. The remaining 20% is sold to private buyers based mainly in Mombasa (Kenya) but whose clients are all over the world (MINECOFIN, 2014). About 60-65% of Rwandan tea goes to Pakistan, of the 20 % sold to private buyers and the main grades from the top gardens are mainly sold in UK and USA (NAEB, 2015). The balance is sold to Egypt, Middle East, South Africa, Sudan, Somalia and former Soviet Union States (Gathani and Stoelinga, 2013). Fluctuations in tea and coffee production and prices affect Rwanda's export earnings (MINICOM, 2014).

Exports contributed 15% of GDP in 2014 (World Bank, 2015) and are divided into formal and informal exports. Formal exports are again divided into traditional, non-traditional exports and re-exports. Traditional exports are composed of tea, pyrethrum, coffee, minerals (tin, coltan, and Wolfram), as well as hides and skins. Non-traditional exports are dominated by milling industries, especially food and beverages, edible vegetables, roots, tubers and live animals (MINICOM, 2011). Rwanda re-exports petroleum products, vehicles, machines as well as engines and minerals. The foremost commodities traded in informal cross-border exports are agricultural products and livestock, most of which are exported to neighboring countries such as Burundi, Democratic Republic of Congo, Tanzania and Uganda (BNR, 2010).

Agriculture export sector is one of the vital sectors of the country *vis-à-vis* foreign exchange earnings. Coffee and Tea exports account for 81 percent of agricultural exports earnings and about 20 percent of total Rwanda's goods exports (Broka *et al*., 2016). The export share percentage of GDP from 2000 up to 2015 shows a fluctuation where the highest share was 16% in 2007, the lowest was 6% in 2000, and the recent statistics show that the share was 15% in 2014 (BNR, 2015). Ideally, the national income is the indicator of economic growth, and the exports are one of the vital components in determining the national income. If the level of imports relative to exports is low, the national income level will be better (Were *et al*., 2002). An increase in a country's total exports of goods and services can create jobs, increase foreign exchange earnings, improve the balance of payments and consequently reduce weighty external borrowing (Mabeta, 2015).

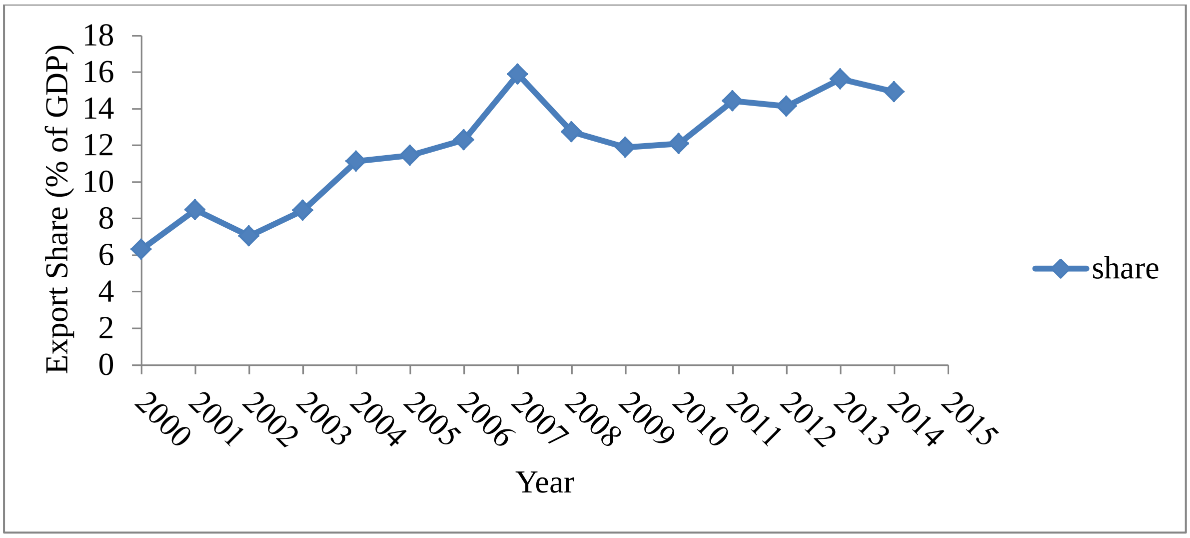



**Figure 1:** The share of total exports to national GDP in Rwanda (2000-2015).

**Source**: WDI, 2016.

To boost exports, Rwanda has set exchange rate policy whose core objective is to preserve the external value of the national currency and also to ensure the effective operation of the foreign exchange market (Mukunzi, 2004). Rwanda introduced a flexible exchange rate regime in 1995, and its key characteristic is a controlled flexible policy (BNR, 2015). The policy's goals are twofold: to stabilize the exchange rate and prices to enhance the economic growth as well as to link that national foreign exchange market to the world market (Mukunzi, 2004). The effect of exchange-rate variability on the volume of international trade has received considerable attention because the end results of exchange rate volatility on trade have long been at the center of the discussions on the optimality of different exchange-rate regimes (Buguk *et al.*, 2003).

### 1.2 Statement of the problem

Tea and coffee are the most important sources of agricultural exports earnings. Efforts have been made to modernize and boost production in these sectors concerning quality and the quantity. However, over the last 16 years, the share of exports to the GDP has been fluctuating considerably. However, it has not been established if the cause is exchange rate volatility. Theoretically, exchange rates and exchange policies have a huge bearing on the performance of the country's exports. However, the role of exchange rate volatility on the export of tea and coffee in Rwanda remains unclear in the empirical literature. This study intended to fill this knowledge gap by conducting and analyzing the effect of exchange rate and exchange rate volatility on agricultural exports.

## 1.3 Objective of the study

### 1.3.1 General Objective

To contribute towards the improved performances of shares of tea and coffee exports to GDP through better exchange rate policy, in Rwanda.

### 1.3.2 The specific objectives

i. To estimate the trend of coffee and tea exports in Rwanda from year 2001 to 2016.
ii. To determine the effect of exchange rate fluctuation on prices of exported coffee and tea from Rwanda to major importing countries from year 2001 to 2016.
iii. To determine the effect of exchange rate fluctuations on the volume of the tea and coffee exported from Rwanda to major importing countries from year 2001 to 2016

## 1.4 Hypotheses

i. There is no significant growth in coffee and tea exports from year 2001 to 2016.
ii. There is no significant effect of exchange rate fluctuation on the price of exported coffee and tea from Rwanda to major importing countries from year 2001 to 2016.
iii. There is no significant effect of exchange rate fluctuations on the volume of exported coffee and tea from Rwanda to major importing countries from the year 2001 to 2016.

## 1.5 Justification of the study

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 improved balance of trade. Agriculture, tourism, and mining sectors are the priority sectors for Rwandan five-year National Export Strategy (NES). Particularly, tea and coffee and the non-traditional horticultural products are central to the realization of the national export strategy (MINICOM, 2011).

The findings of this study will be a valuable source of information to the government and other stakeholders in the formulation of the effective exchange rate and international trade policies to enhance the country's exports. It was intended to generate crucial information useful for policymakers, researchers, economists, the private sector and all actors involved in international trade in Rwanda. The understanding of the effects of exchange rate fluctuation on agriculture exports will boost agricultural exports earnings, which will lead to job creation, overcome trade balance deficit and ultimately reduce poverty.

### 1.6 Scope and limitation of the study

This study assessed the effect of exchange rate and exchange rate fluctuation on two keys agricultural exports in Rwanda which are coffee and tea, exported from 2001 to 2016 using monthly time series data. Although Rwanda has three traditional export cash crops, this study was limited to coffee and tea because they are the leading regarding the quantity and revenue.

### 1.7 Definition of terms

**Agricultural export**: selling of agricultural commodities produced in the home country to the foreign markets.

**Exchange rate:** The Rwandese Francs equivalent of the currencies of the major trading partners

**Exchange rate fluctuation**: exchange rate fluctuations here are interpreted as the instability in the value of a certain currency in a certain period *vis-à-vis* the USD.

**Trade balance:** is the difference between the value of exports and the value of imports.

**Traditional export**: is defined as well long known home-produced goods sold to international markets and in Rwanda, which are: coffee, tea, pyrethrum, minerals.

# CHAPTER TWO
# LITERATURE REVIEW

This chapter reviews the work of different scholars conducted in the area of agricultural export on exchange rate fluctuation and their theoretical underpinnings. The subsequent two sections provide an overview of the coffee and tea sectors in Rwanda. The following part reviews some empirical studies on the effect of exchange rate and exchange rate fluctuation on agriculture exports. The chapter concludes with the summary of the theories behind the study (theoretical framework) and conceptual framework.

## 2.1. Overview of the coffee and tea sectors in Rwanda

### 2.1.1. Coffee in Rwanda

According to Nzeyimana *et al*. (2013) coffee has played a considerable role in the socio-economic development of the country by contributing significantly to foreign exchange earnings and the monetization of the rural economy. Coffee sub-sector is harmonized under the National Agricultural Export Development Board (NAEB). The responsibilities of NAEB are: to support the coffee production by offering technical assistance and planting material to farmers. To support the processing, the promotion, the marketing, and the export of Rwandan coffee, participate in the development of the policy and strategies governing the sector and ensure the implementation of policies as they affect production, processing, marketing research and training in the sector (NAEB, 2014).

Most of the Rwandan coffee is exported to European countries whereby 42% of the coffee exported goes to Switzerland, 15% to the United Kingdom, 10% to Belgium, 19% to America, 8% to Uganda, 1% to Kenya and the remaining 5% goes to Asian countries and other importers. Coffee exporting companies have risen from 5 in 2002 to 68 in 2015 (NAEB, 2015). Coffee production has gradually increased over time attaining a peak in the mid-1980s. In 1987 about 43,000 metric tons (MT) of semi-washed coffee was produced (Figure 2). During subsequent years, production dropped to an annual average of 26,000 MT mainly due to ageing coffee trees, a decline in soil fertility, low coffee prices to the farmers, and the 1994 genocide (Hartemink and Graaff, 2013).

The price of coffee cherries paid to farmers increased from Rwf250 to 1,200 per kg between 2000 and 2010. Coffee has again become one of the country's leading exports, with its production increased by 20% and coffee exports increased by 150% in the same period

(NAEB, 2011). Despite little overall growth in the quantity of full washed coffee, Rwanda's coffee industry has gained a positive profile and created tremendous demand for its high-quality bourbon Arabica (NAEB, 2014).

However, despite impressive progress in transforming the Rwandan coffee sector, the sector is currently falling short of the targets it set itself in 2002. The current most important constraint to growth is the insufficient production of coffee cherries. This, combined with high operating costs and weak management skills, has resulted in many washing stations struggling to turn a profit and deliver on sales commitments. The planned move towards value addition in coffee over and above the introduction of washing stations has also been slower than anticipated (MINAGRI, 2012).

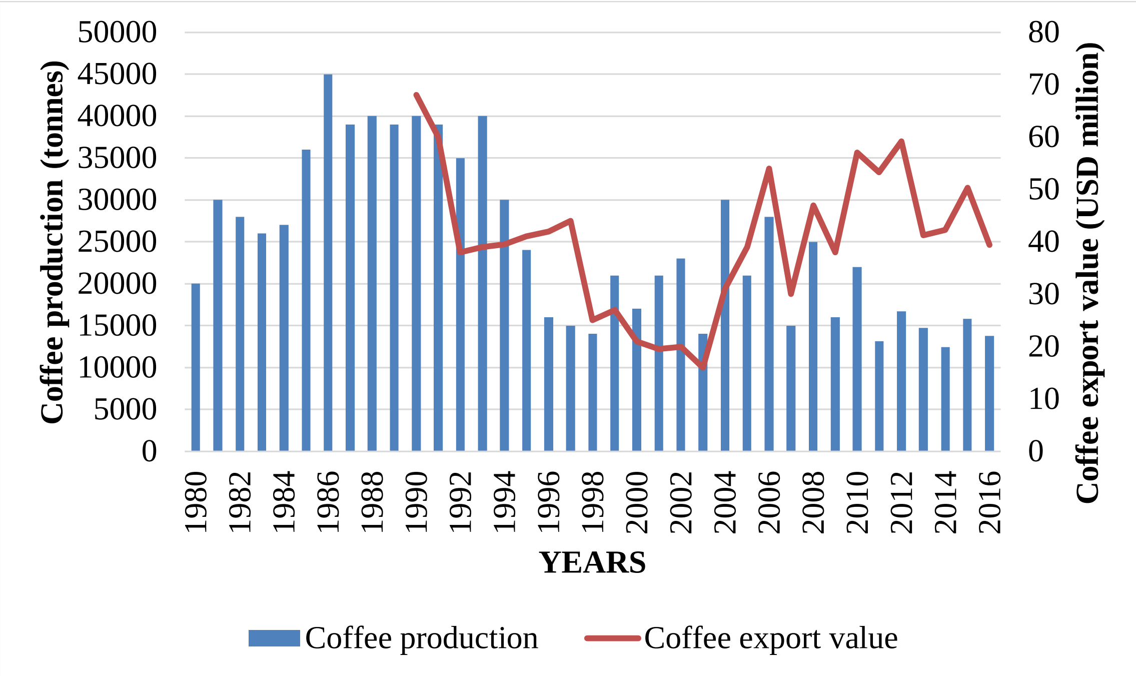



**Figure 2:** Coffee production and export value in Rwanda between 1980 and 2016

**Source:** Author's computation based on data obtained from NAEB and NISR (2017)

### 2.1.2 Tea in Rwanda

Today, tea industry is comprised of fourteen operational factories and two tea projects. Most processed tea in Rwanda is black tea (CTC). However green tea and orthodox tea are produced in small quantities while spicy tea is processed by order. The production of tea has increased steadily, from 60 tons of black tea in 1958; about 1,900 tons in 1990; and 14,500 tons in 2000 and reaching at the peak of 24,800 in 2014 (NAEB, 2015). To increase the productivity, the production, and the export revenues, the government of Rwanda implemented privatization program of tea factories starting with Pfunda tea factory in 2004 and ended in December 2012 with Mulindi and Shagasha tea factory (NAEB, 2014).

In 2011, the first international tea convention and exhibition held in Mombasa and brought together over 27 tea-producing countries, Rwandan teas took two out of the three top positions in a tea-tasting competition held on the sidelines of the convention. It was also the same scenario on the second Africa tea convention organized in Rwanda Serena Hotel in August 2013. Where the three first place and overall in primary grade was won by Rwanda factories with best quality Pekoe Dust (PD) for Karongi, Broken Pekoe 1 (BP1**)** for Gisovu and Pekoe Fannings 1 (PF1) from Kitabi respectively. Kitabi factory became the overall winner for all grades (NAEB, 2013).

To encourage local and regional consumption, Rwanda has put more emphasis on value-added tea with an introduction of single estate tea product in Sorwathe Tea Factory (MINECOFIN, 2014). Considering Rwandan value-added tea, support is given to tea factories in acquiring quality certifications as well as facilitating tea farmers with agronomical practices (Ocaya *et al*., 2013). NAEB advised all factories to be ISO 22000:2005 certified for safety assurance. Private standards are diverse depending on different markets. Preference should be based on the target market. Four privates Certification Standards dominate on the global market; Rain Forest Alliance, UTZ, Fair Trade and Organic (NAEB, 2014).

### 2.2 Overview of exports and exchange rate

Exports of goods and services are the value of all merchandises and other market services supplied overseas. They take account of the worth of commodities, insurance, freight, transport, travel, royalties, license fees, and other services, such as construction, communication, financial, information, business, personal, and government services. They exclude investment income, compensation of employees (previously called factor services), and transfer payments (World Bank, 2013). Less developed nations are more dependent on foreign trade on the subject of its share in national income than the highly developed countries are. Primary products accounted for a sizeable proportion of individual gross national product (GNP) from (25% to 40%), (Todaro and Smith, 2015).

Most studies (Zhang and Buongiorno, 2010; Van and Lin, 2011) of world demand patterns for different commodity groups reveal that in the case of primary products, the income elasticity of demand is relatively low. Moreover, since the price elasticity of demand for (and supply of) primary commodities also tends to be inelastic, any shifts in demand or supply curves can cause large and volatile price fluctuations. Together these two elasticity phenomena contribute to what has come to be known as export earnings instability, which has been shown to lead to lower and less predictable (Todaro and Smith, 2015). Export dependence is country's reliance on exports as the major source of financing for development activities. As noted by Harvey *et al*. (2012) for 40 countries, the production of three or fewer commodities explains all export earnings. UNCTAD reported in 2006 that 67.4% of developing countries are more than 50% dependent on commodity exports and for most in sub-Saharan African countries, the figure is 80%.

A country's official exchange rate is the rate at which its central bank is prepared to transact exchanges of its local currency for other currencies in approved foreign-exchange markets. Official exchange rates are usually quoted in terms of United States dollars (Todaro and Smith, 2015). According to the Bank for International Settlement report, (2013) the foreign exchange market is by far the biggest and most liquid financial market in the world. The foreign exchange market is primarily made up of three inter-related parts; forward transaction, spot transaction and derivative contracts (Broll and Hansen-Averlant, 2010). The currency market as for other financial markets can be volatile; the volatility is usually defined as the standard deviation or variance of the returns of an asset during a given period (Pilbeam and Langeland, 2015).

Exchange rate fluctuation influences the volume and prices of international trade in the long term, but short-term dynamics vary by commodity (Zhang and Buongiorno, 2010). The term fluctuation or volatility represents the directionless variability of an economic variable as represented by the dispersion of the variable within a given time horizon (Prakash, 2011). Variability refers to the extent to which an economic variable such as an exchange rate or price moves up and down over time referring to its mean (Harwood *et al.*, 1999). Typically in economic theory, fluctuation connotes two principal concepts: variability and uncertainty (Prakash, 2011). An exchange rate is the value (price) of one foreign currency in local currency (Sadoulet and De Janvry, 1995).

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. On the other side, floating exchange rate allows up and down movement of currency minute by minute (Clark *et al.,* 2004). Main factors like interest rate, inflation and the state of politics and economics influence exchange rate in every country (Pugel, 2007). Exchange rate volatility refers to the extent to which the prices of currencies tend to fluctuate over time (Broda and Romalis, 2004). Based on theory, the exchange rate is a source of uncertainty which tends to impact on risk-averse traders or exporters, thus reducing or increasing exports (Cote, 1994).

Theoretically, There are two schools of thought; traditional and risk-portfolio which contrasts while explaining the effect of exchange rate volatility on exports and. the traditional school of thought which 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 a 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 imports.

High exchange rate volatility sends conflicting signals to investors as it creates vagueness about their profits. Exchange rate volatility is important as it creates gains or losses to farmers and exporters. These unexpected losses cause exchange rate risk thus discouraging production, and this affects volumes of trade leading to adverse effects on economic growth. Further, exchange rate volatility affects international price competitiveness of exports leading to resource reallocations, which has a bearing on economic efficiency (Pugel, 2007). The total value of export earnings depends not only on the volumes of these exports traded abroad but also on the worth paid for them (Faridi, 2012). Domestic agriculture is capable of contributing beneficially to the balance of overseas payments either by augmenting the country’s export earnings or by expanding the production of agricultural import substitutes.

### 2.2.1 Agricultural exports in Rwanda

Economic Development and Poverty Reduction Strategy two (EDPRS II ) set out targets to increase exports revenues from US$1.277 billion in 2013 to US$4.515 billion in 2018 or approximately 29% average annual growth over the next five years (MINICOM, 2014). Rwanda's merchandise exports remain concentrated in a few crucial commodities (traditional exports) tea, coffee, and minerals. In 2008, Rwanda's traditional exports amounted at 69% reducing to 45% and still significant in 2014. Traditional exports averaged 10% growth between 2008 and 2014 mainly driven by increase in mineral exports. Over the same period, non-traditional exports averaged 22% growth, re-exports 22% growth and informal exports 25% per year (BNR, 2015). Traditionally, agriculture export commodities comprise coffee, tea, and pyrethrum. Nonetheless, in the recent past, the scale of agricultural export crop development has extended to include crops such fruits, flowers, vegetables and new export value chains inclusive of livestock products, cereals, and grains to name a few (NAEB, 2014).

In the coffee value chain, the 2014-2015 fiscal year registered a production of 16,924 MT and exports of 16,529 MT that generated an export revenue of USD 64.02 million. The cumulative tea production from July 2014 to June 2015 was 25,619 MT, and the corresponding exports were 24,848MT with export revenue of USD 61.81 million (NAEB, 2015). During the period under review, the average quantity of fruits and vegetables sold in the export markets was 23,418 MT and valued at USD 6.68 million. Other exported commodities include pyrethrum, which generated a total of USD 1.79 million from 9.9 MT of exports (BNR, 2015). Livestock products including beef, milk, live animals, hides, and skins were among other new export commodities and generated a total of USD 63.62 million. Cereals and grains exported to regional markets injected USD 44.53 million while roots, tubers, fish, banana, and pulses generated USD 29.89 million in nation economy. For the key exports developments, (value FOB in USD million, volume in thousands of tons) Table 1.

**Table 1:** Rwandan major exports development

| | | July 11 - June 12 | July 12 - June 13 | July 13 - June 14 | July 14 - June 15 | % change |
|---|---|---|---|---|---|---|
| **Coffee** | Value (USD) | 78.41 | 69.09 | 47.49 | 64.03 | 34.8 |
| | Volume (tone) | 16.73 | 20.53 | 17.83 | 16.53 | -7.3 |
| **Tea** | Value (USD) | 61.09 | 63.89 | 52.26 | 61.68 | 17.8 |
| | Volume (tone) | 22.31 | 22.06 | 21.73 | 24.79 | 14.1 |
| **Minerals** | Value (USD) | 148.36 | 186.31 | 204.28 | 174.1 | -14.8 |
| | Volume (tone) | 8.83 | 8.41 | 10.23 | 9.04 | -11.7 |
| **Cassiterite** | Value (USD) | 77.3 | 57.12 | 68.43 | 53.34 | -22.1 |
| | Volume (tone) | 6.32 | 4.67 | 5.65 | 4.87 | -13.7 |
| **Coltan** | Value (USD) | 45.29 | 102.22 | 106.38 | 97.09 | -8.7 |
| | Volume (tone) | 0.98 | 1.75 | 2.29 | 2.09 | -9.1 |
| **Wolfram** | Value (USD) | 25.76 | 26.96 | 29.46 | 23.66 | -19.7 |
| | Volume (tone) | 1.53 | 1.99 | 2.29 | 2.08 | -9.1 |
| **Hides and Skins** | Value (USD) | 9.37 | 16.68 | 17.09 | 12.15 | -28.9 |
| | Volume (tone) | 7.21 | 10.91 | 10.99 | 8.96 | -18.5 |
| **Pyrethrum** | Value (USD) | 5.76 | 9 | 1.61 | 1.55 | -3.8 |
| | Volume (tone) | 0.02 | 0.04 | 0.01 | 0.01 | -6.3 |
| **Re-exports** | Value (USD) | 63.05 | 133.83 | 167.18 | 150.14 | -10.2 |
| | Volume (tone) | 37.12 | 78.29 | 105.35 | 122.33 | 16.1 |
| **Other export** | Value (USD) | 63.03 | 95.7 | 86.73 | 117.79 | 35.8 |
| | Volume (tone) | 121.85 | 181.15 | 139.67 | 181.43 | 29.9 |
| **TOTAL EXPORTS** | Value (USD) | 429.07 | 574.49 | 576.64 | 581.43 | 0.8 |
| | Volume (tone) | 214.06 | 321.39 | 305.81 | 36308 | 18.7 |

**Source:** BNR Statistics Department, 2016

Table 1 shows a positive percentage change for a few export commodities. While mining and pyrethrum which are the part of traditional export indicate negative percentage change, it is a bad sign. Rwanda relies on traditional export earnings to overcome trade balance. The public and private partnership is the key factor to promote exports which need consistent production, good business environment, trust, trading skills especially in enforcing the contract for exporters on both sides domestic and international (Boudreaux, 2008).

Export companies with a turnover above $1 million (Million Dollar Exporters representing 3% of the number of exporting firms in 2014) accounted for 84% of export value in the same year. These firms can compete and survive in export markets. Twenty-six exporters (40%) in 2013 grew from being small exporters to medium and developed exporters (MDEs) over the past five years. With this potential, this calls for Rwanda to support firms with the potential in repeating this success (NAEB, 2015). Rwanda exports to a large number of markets across the globe. The Democratic Republic of Congo (DRC) is Rwanda's largest single export destination accounting for 13.3% of formal merchandise exports in 2014 up from 6% in 2008. The DRC is also one of Rwanda's fastest growing markets averaging 34% per annum for the past seven years.

The East Africa Community's (EAC's) market share was 21% in 2014 with growth averaging 19%. The broader African market has seen its share of exports decline rapidly since 2008, decreasing from 14% to just 1.7% of exports by 2014 and registering an average annual growth rate of -17% per annum (BNR, 2015). The European market remains significant, 39.2% of exports counted in 2014, up from 38% in 2008, with exports averaging 18% growth per annum. Since 2008, Asia accounted for 15.2% of exports in 2014 with 14% average growth annually (MINICOM, 2014). Exports are essential to achieve the Rwanda 2020 vision economic goals. Where export growth is intended to grow at 15% rate annually and is marked as a fundamental component to achieve the trade balance, and improve the balance of payments. Thus far, this effort has contributed to the balance of payments deficit reduction from 17% of GDP in 2001 to 9% in 2010 (MINICOM, 2011).

### 2.2.2 Exchange rate in Rwanda

Rwanda has an exchange rate policy (accommodative monetary poly), and its core objectives are to preserve the external value of the national currency and also to ensure the effective operation of the foreign exchange market. The rate of exchange and exchange regulations are used as instruments to carry out exchange rate policy. The latter comprises all the arrangements resulting from the legislative texts and lawfully taken by the government to supervise the management of foreign currencies (BNR, 2014). Rwanda had an administered economy, which imposed severe restrictions on trade and foreign exchange transactions and a fixed exchange rate regime (1961-1990). By the early 1990s, the average tariff rate was 34.8%, with five different tariffs ranging from 0-60%.

Every import and every importer was subject to a quota, and all import operations were subject to a license authorizing external currency disbursement. Exporters had to repatriate currency generated by the sale of exports as a legal requirement. Export licenses were approved only by the National Bank of Rwanda. More importantly, all export earnings were transferred to and managed by the NBR (Nibeza and Tumusherure, 2015). The period from 1991 until 1994 corresponds to the beginning of the removal of restrictions on trade and foreign exchange transactions, and the gradual revival of a market economy, Rwanda embraced a market economy characterized by the continuation of trade reforms and a liberalization of the monetary and financial regimes (Mukunzi, 2004).

The flexible exchange rate regime was established in 1995, and at the same time, the organization and the management of the foreign exchange market were entrusted to the Central Bank. Tariffs were reduced considerably at the decreasing average rate of 18%, and there remained four tariff bands with a maximum of up to 30% by 2003 (Maniragaba, 2016). The flexible exchange rate is the exchange value of a national currency that is free to move up and down in response to shifts in demand and supply arising from international trade and finance (Todaro and Smith, 2015). The characteristic of the Rwanda flexible exchange rate regime is that it is a controlled flexible policy.

The mentioned policy pursues three focal goals: to approach as much as possible the balance level of the rate of exchange, the price stability and the support for the growth, as well as to connect the Rwandan foreign exchange market to the international markets (Khan, 2010). With the help of international institutions such as the International Monetary Fund and the World Bank, the Central Bank of Rwanda is trying to follow an objective which entails developing a careful exchange rate and monetary policy harmony (Nibeza and Tumusherure, 2015). To this effect, the National Bank of Rwanda through Monetary Policy Committee (MPC) has kept a flexible exchange rate regime, intervening on the domestic, foreign exchange market to smoothen excessive exchange rate volatility (Rwangombwa, 2014).

Further foreign Reserves Management is one of the pillars of National Bank of Rwanda and from this pillar, the target is to manage foreign reserves well and more efficiently to guarantee at least four months of import cover with a benchmark return of 0.5% annually. Currently, the National Bank of Rwanda holds foreign exchange reserves in order to cover needs of foreign exchange and external obligations, to support exchange rate management and monetary policies, absorb shocks and limit external vulnerability during crises times

(Nibeza and Tumusherure, 2015). The Rwandan Franc (Rwf) experienced same pressure in 2014/2015 and continued to suffer from the persistent wide trade deficit. Because of the United State of America dollar (USD) which kept strengthening against most of the currencies used around the world; and the speculation resulting from the depreciation of currencies from major trading partners in East Africa Community (EAC) (BNR, 2015).

### 2.2.3 Exchange rate fluctuation

Exchange rate volatility is the movement (instability) in the price of home currency in the external reference currency, which in this work is the Rwandan francs against USD (Rwangombwa, 2014). The deviation of the exchange rate over time from equilibrium or a benchmark is called exchange rate volatility (Azeeze, *et al*. 2012). Rwanda embraces flexible exchange rate policy which means it likely to have high exchange rate volatility since that regime allows the up and down movement in the exchange rate according to the market demand and supply (Nibeza and Tumusherure, 2015). Exchange rate volatility is meaningful in cross-border trade and it needs well designed monetary policy and the good understanding of traders to make it profitable as a usual shock (Bruneau and Moran, 2015). The effects of exchange rate fluctuation on trade have been under discussion from the introduction of flexible exchange rate policy but are not really well known. They are always unique depending on the product term of trade and so many other factors (Pugel, 2007).

## 2.3 Summary of empirical findings

It has been revealed that different studies have employed different models to look at the effect of exchange rate fluctuation on different export sectors performance. Kiptui (2008) studied the impact of real exchange rate on the demand of Kenya's exports in an export demand framework which includes Kenya's agriculture major export coffee, tea, horticulture, and manufactured goods. A bound testing and auto-regressive distributed lag (ARDL) approaches to the analysis of long-run relationship and error correction modeling was applied. The existence of the long-run relationship is established for tea, coffee and horticulture export but rejected for manufactured goods exports. In short-run results show that the real exchange rate has a positive effect but found to be statistically insignificant.

Barret (2007) estimated effects of exchange rate volatility on export volumes using the multivariate generalized autoregressive conditional heteroscedasticity in mean (MGARCH-M) model. The change in the expected exchange rate and change in industrial production of importing country jointly influence agricultural export volume but not in other sectors. In another study on exchange rate volatility influence on French beans export in Kenya by Mwangi *et al.* (2014), using the generalized autoregressive conditional heteroscedasticity (GARCH) model reported a negative relationship between exchange rate volatility and French beans export.

### 2.4 Theoretical and conceptual framework

#### 2.4.1 Theoretical framework

The study is underpinned by open macroeconomic theory linking exchange rate volatility, economic openness and the volatility of exchange rate fundamentals (Mpofu, 2016). This theory explains the effects of fixed and flexible exchange rates on trade in small and large open economies. Exchange rate, which is defined by the price at which exchanges between countries takes place, is determined by net exports and trade balance (Jabeen and Khan, 2014). In an open economy, as in closed economy, financial markets and goods markets are closely related, and the national income account identity shows the relationship between the international flow of funds equal worldwide flow of goods and services (Blanchard and Johnson, 2013).

In economic theory, the traditional school of thought, for instance, (Clark, 1973; Baron, 1976; Hooper and Kohlhagen, 1978) hypothesized that higher volatility increases risk and therefore depresses trade flows. On the other hand, the risk-portfolio school based on theoretical studies by Broll and Eckwert (1999), Dellas and Zilberfarb (1993) and De Grauwe (1988) maintain that higher risk presents a better opportunity for profit and should increase trade. Traditionalists believe that exporters are either risk-averse, risk neutral or risk loving and thus react differently to volatility in exchange rates.

If agents are risk neutral, exchange rate volatility does not affect the exporters' decision. When agents are risk averse, an increase in exchange rate volatility induces them to reduce the volume of exports by reallocating production towards domestic markets. The risk-portfolio claims that the traditionalists are unrealistic. The main objection against the traditional school by the risk-portfolio school of thought is that it does not appropriately model how firms manage risk. The theory postulates that the result of an increase in the exchange rate volatility depends on the convexity of the utility function, which in turn depends on the level of risk aversion. For the highly risk-averse, a rise in exchange rate volatility leads to an increase in the utility of forex and encourages exporters to export more to avoid the risk of a decline in their revenues.

This is referred to us as the income effect of exchange rate volatility. The less risk-averse agents consider an increase in exchange rate variability as a greater risk. Thus increased exchange rate volatility makes these players reduce exports and switch resources to other sub-sectors. This refers to us as the substitution effect of exchange rate volatility. Thus exports raise with increase in exchange rate volatility; the greater the income effect while exports decline if the substitution effect outweighs the income effect. Thus higher income effects over substitution effects can lead to a positive relationship between trade and exchange rate volatility. With short measurement periods, the series of the deviations of the rate of change of exchange rate from the mean tend to be serially correlated, indicating sustained periods of high or low volatility (Baillie and Bollerslev, 1990).

Accordingly, since their introduction by Engle *et al.* in (1987), Autoregressive Conditional Heteroskedastic (ARCH) models have become customary in measuring volatility of exchange rate (Diebold and Nerlove, 1989). With this respect, the ARCH model develops over the moving standard deviation of the pace of change used, for example, by permitting for persistence of exchange rate variability (Sun and Zhang, 2003). More efficient estimation is obtained with Generalized Autoregressive Conditional Heteroskedastic (GARCH) models (Bolerslev, 1986) who found that the exchange rate volatility in general had a little effect on USA exports and prices (Zhang and Buongiorno, 2010). Econometric literature supports the utilization of autoregressive moving average (ARMA) specifications as a suitable, reduced form method the balanced expectations processes of uncertain lag structure can be captured (Feige and Pearce, 1976; Nerlove *et al.,* 1979; Wallis, 1980). This study followed that tradition.

### 2.4.2 Conceptual Framework

Factors that influence exchange rate to fluctuate can be placed into two broad classes; the demand side and supply side. Supply-side includes those push factors that give a country the drive to export goods and services. They are factors that directly affect the production ability of a country. These include among many other variables: Domestic relative price, real foreigner income, and exchange rate volatility. The exogenous factors such as trade agreements and seasonality in the agricultural sector could affect production and hence the volume of exports.

On the other hand, demand factors are those factors that pull a foreign country to import goods and services from another country. Higher incomes, for instance, increase the purchasing power of the importing country and thus resulting in increased imports of goods and services. Figure 3 below illustrates the relationship between factors influencing exchange rate fluctuations and their effect on the volume of exports.

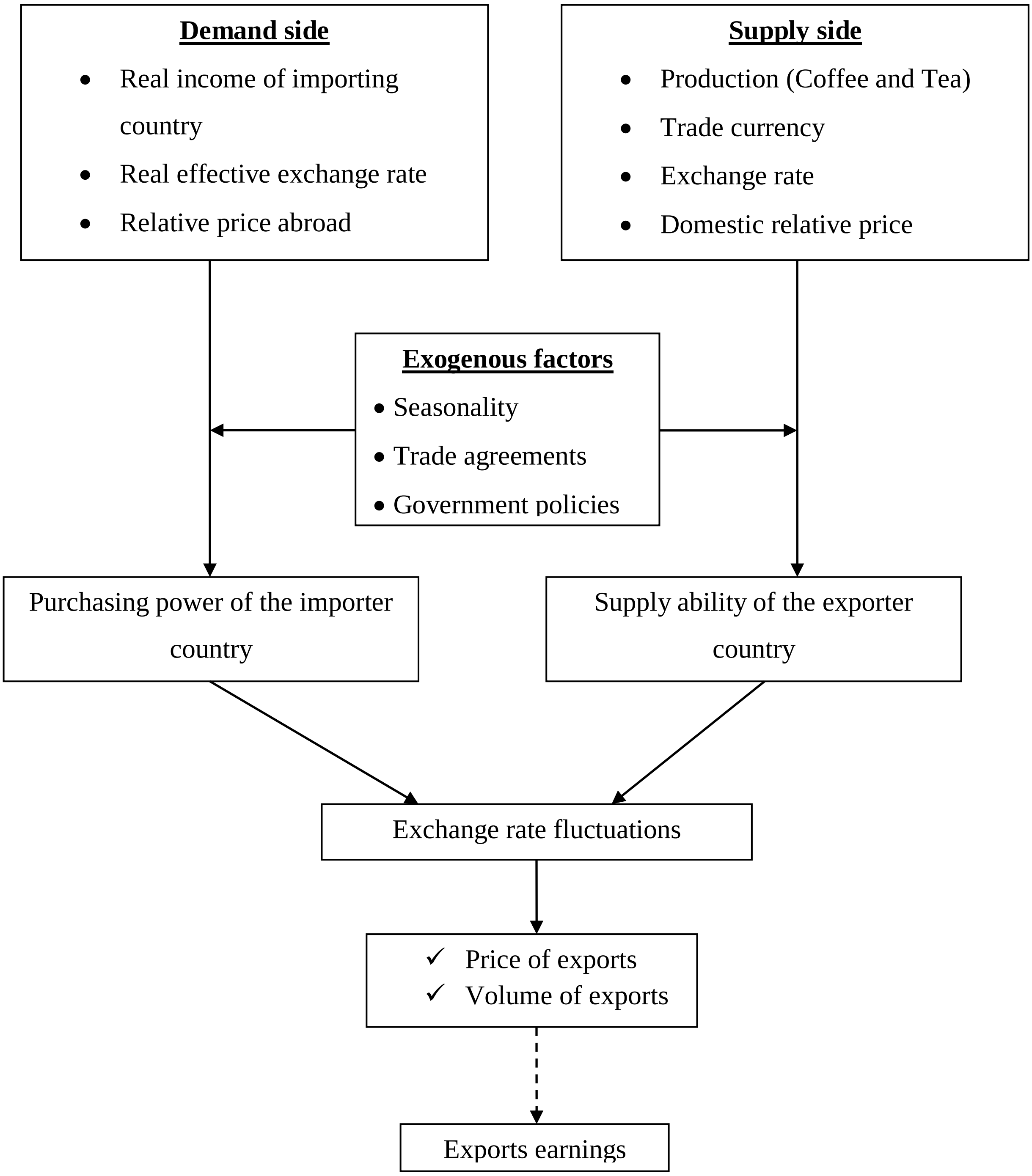



**Figure 3**: Conceptual framework

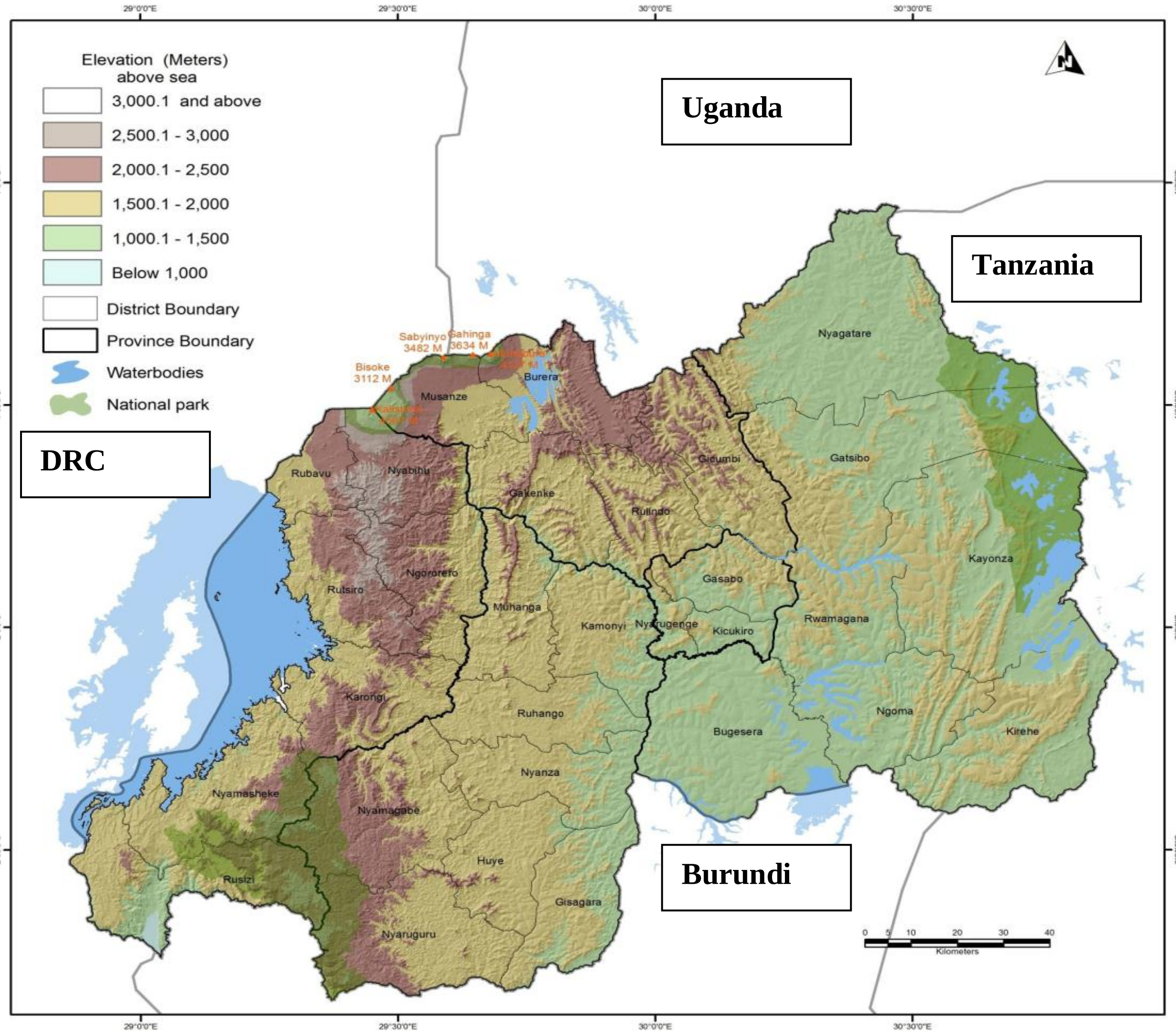
# CHAPTER THREE
# METHODOLOGY

## 3.1 Study area

The study was conducted in Republic of Rwanda, located in East Africa and belongs to East African Community (EAC). The capital city, Kigali is situated near the center of the country. Rwanda is divided into provinces, and the smallest politico-administrative entity is a village. According to the 2012 census, the population of the citizens was 10, 515, 973 at a proportion of 52% women and 48% men. Further, Rwanda is landlocked and the most densely populated country in EAC (NISR, 2012). Rwanda is bordered by Democratic Republic of Congo to the West, Uganda to the North, Tanzania to the East, and Burundi to the South. It is found in latitude and longitude lines of (1°02′40″ and 2°50′16″South) and (28°51′29″ and 30°53′56″ East) respectively (Sirven *et al*., 1973).

Its relative distance to prominent ports stands as thus; 1,100 Km from Mombasa Port (Kenya), 1,920 Km from Matadi Port (Democratic Republic of Congo), 3,980 Km from Cape Town (Republic of South Africa) and 3,750 Km from Cairo (Egypt) (MINICOM, 2014). The entire country is at high altitude. The topography composes of four main areas: the Congo Nile Ridge, central plateau, eastern lowland zone and Bugarama Plain. It is dominated by mountains hence called the land of a thousand hills (RoR\REMA, 2011). Rwanda's climatic conditions vary spatially and temporary. Although it is entirely situated within the equatorial zone, it enjoys a moderate tropical climate due to high altitudes and temperatures average 20°C. Rainfall follows a bimodal cycle although it is abundant throughout the year (Prioul and Sirven, 1981).

Rwanda is endowed with abundant water resources consisting of some lakes, marshland, and rivers. The environment, coupled with plenty waters favors the production of coffee and tea which are the country's agriculture export base (Figure 2). Coffee is mainly grown in central at moderate mountains and hills as well as on the coast of Lake Kivu in the western province. In 2010, coffee trees covered 2.3% of total cultivated land and are grown mostly by smallholder farmers on the surface of less than one hectare (NAEB, 2015). Further, tea is found in all provinces of Rwanda except eastern province and Kigali city the Western and Northern provinces are the major producing areas with about 80 percent of total country production. NAEB (2012) reported that tea occupies 25, 000 ha of cultivated land. Rwanda map (figure 4).




**Source:** BNR statistics department, 2016

**Figure 4:** Map of Rwanda

### 3.2 Method of data collection

The study used secondary monthly time series data on bilateral exports and real effective exchange rates from January 2001 to December 2016 for coffee and tea. This period was chosen because of the availability of reliable data after six years of genocide and war which paralyzed the Rwandan economy in all sectors. Other time series data on real exchange rates, coffee export volume, tea export volume, coffee export prices, and tea export prices 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).

### 3.3 Method of data analysis

For objective one; to evaluate the developmental trajectory of tea and coffee exports in Rwanda from 2000 to 2015, descriptive statistics such as the mean, standard deviation, and the median was used, and Trend analysis was also employed to find out the direction and the behavior of the trend. Finally, the analytical model was specified in such a way that export volumes from either crop were regressed on time. This method was also used by Mabeta (2015). If the slope coefficient in the model is positive, then there is an upward trend on the volume of exports, whereas if it is negative, it implies that there is a downward trend in export volumes on the crop under investigation, and if it is constant then there is no change.

To estimate the growth of coffee and tea exports, the volume of exports of either crop in natural log form was regressed on time, t. The growth rate model was specified as follows:

$$E_{tj} = \beta_1 + \beta_2 t + u_t \tag{1}$$

$$\ln E_{tj} = \beta_1 + \beta_2 t + \mu_t \tag{2}$$

Where $\ln E_{tj}$ is export volume at time *t* of commodity *j* in this case either coffee or tea, $\beta_1$ is the intercept, t is trending variable $\beta_2$ is the slope coefficient and $u_t$ is error term. $\beta_2$ is expected to be positive or negative. Models like (2) above are known as semi-log models or log-lin models since one of the variables is in logarithmic form.

The slope coefficient, $\beta_2$ measures the proportional or relative change in $\ln E_{tj}$ for a given absolute change in the value of the regressor, t, that is

$$\beta_2 = \frac{proportional \quad change \quad in \quad regressand}{absolute \quad change \quad in \quad regressor}$$

(3)

$\beta_2$ can also be interpreted as the partial elasticity of $E_{tj}$ with respect to *t*. Multiplying (3) by 100 gives the percentage change or the growth rate in $E_{tj}$ for an absolute change in t, the regressor. The coefficient of the trend variable in the growth model (2), $\beta_2$ gives the instantaneous (at a point in time) rate of growth and not the compound (over a period) rate of growth (Gujarati and Porter, 2009).

$$Numerically, \quad \beta_2 = \frac{d(\ln y)}{dx} = (1/y)\left(\frac{dy}{dx}\right) = \left(\frac{dy}{y}\right)\Big/dx \tag{4}$$

This is the same as (3) above. To obtain the compound growth rate of coffee and tea exports, the antilog of the estimated $\beta_2$ was subtracted by 1 and the difference multiplied by 100. That is, the growth rate of coffee or tea exports was given by $\left(e^{\beta_2} - 1\right) \times 100$. For the objective two and three, To determine the effect of exchange rate and its fluctuations on the volume, and the prices of the agricultural products exported from Rwanda to major importing countries. The following model was used.

An exploration of the relationship among Rwandan agricultural exports, real exchange rates, and exchange rate variability begins with an examination of integration properties of the data, undertaking co-integration analysis, and examining Granger causality tests based on error correction model. Specifying this econometric model, three further issues was taken into consideration: (i) appropriate lag specification for both the autoregressive moving average (ARMA), and distributed lag terms in the model; (ii) prospective time-varying correlation in the trade volume or price and exchange rate equations' regression errors; and (iii) potential non-normality in the regression errors. These issues are tackled in turn in introducing our estimation framework.

Based on the assumption that there are expectations about the real exchange rate series which follow an ARIMA process. Also, an important assumption is made where the conditional variance is specified as a GARCH process. These can be specified in equation 4 through 7 as follows:

$$\mathrm{A}\varphi_m(L)DLX_t = \gamma_0 + \mathrm{A}\varphi_m(L)\varepsilon_{1,t} \tag{5}$$

$$\varepsilon_{1,t} = \mathrm{Z}_t \sqrt[2]{h_t} \tag{6}$$

$$Z_t \sim N(0,1) \tag{7}$$

$$h_t = W_0 + \sum_{j=0}^{q} \alpha_j \varepsilon_{1,t-j}^2 \sum_{k=1}^{p} \beta_k h_{t-k} \tag{8.1}$$

$$h_t = W_0 + \sum_{j=0}^{q} \alpha_j \varepsilon_{1,t-j}^2 \sum_{k=1}^{p} \beta_k h_{t-k} + \eta S_{t-1} \varepsilon_{1,t-j}^2 \tag{8.2}$$

$DLX_t$ is the first difference in the natural logarithm of the real exchange rate concerning the previous period. It represents the percentage fluctuations in the monthly real exchange rates. Stationarity was tested by using the Augmented Dickey-Fuller (ADF) test, the residuals, $\varepsilon_{1,t}$, in equation (5) 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 (8.1), was used to examine the dynamic conditional exchange rate volatility. The GARCH model allows $h_t$ to vary over time and is modeled as a function of the lagged squared residuals $\left(\varepsilon_{t-k}^{i}{}^{2}\right)$ as well as the conditional variance $\left(h_{t-k}^{i}\right)$. Glosten *et al*, 1993. Suggested a Glosten, Jagannathan and Runkle GARCH (GJR-GARCH(*p*,*q*)) conditional variance specification (equation 8.2) to maintain the tractability of conventional GARCH models while accommodating a leverage effect by adding a term to permit asymmetry in the GARCH model. The leverage effect variable $S_{t-1}$ takes on the value of 1 if $\varepsilon_{1,t-1} < 0$, and $S_{t-1} = 0$ otherwise. The leverage effect is captured by the parameter $\eta$ ; if $\eta = 0$ the GJR model reduces to the conventional GARCH specification. The imposed restrictions are as such as

$W_0 > 0; \beta_k \geq 0, \forall k; \alpha_j \geq 0, \forall j, and \eta \geq 0$. 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 (8.2) has to less than one 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 (DLRX$_t$), as specified in equation (5) (AR(1)-GARCH(1,1) process) is then used to derive the successive periods $\left(DLRX_{t-k2}^{e}\right)$ for *k2*-period-ahead and $\left(h_{i,t-k3}^{e}\right)$ for *k3*-period-ahead changes in the expectations of the real exchange rate (conditional variance estimates for exchange rate risk).

$$DLRX_t^e = \gamma_0 \sum_{i=0}^{k-1} \varphi_1^i + \varphi_1^k DLRX_{t-k} \tag{9}$$

$$h_t^e = w_0 \sum_{i=0}^{k-1} \beta_1 + \alpha_1 k_1^{k-1} \varepsilon_{1,t-k}^2 + \beta_1^k h_{1-k} \tag{10}$$

The DLRX$_t$ series is then undifferentiated back to exchange rate levels $\left(RX_{t-k2}^{e}\right)$, which indicates the expected level of exchange rate while $h_{i,t-k3}^{e}$ reflects exchange rate volatility. The expected values are regressors in the model as specified in equation (11). 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, the 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:

$$LnQ_{i,t} = \delta + \sum_{k1=1}^{a} \delta_{1,k1} \ln(IP_{t-k1}) + \sum_{k2=1}^{b} \delta_{2,k2} \ln(RX_{i,t-k2}^{e}) + \sum_{k3=1}^{c} \delta_{3,k3} \ln(h_{i,t-k3}^{e}) + \sum_{k4=4}^{d} \delta_{4,k4} S_{k4,t} + \sum_{k5=1}^{e} \delta_{5,k5} \ln(Q_{i,t-k5}^{e}) + \varepsilon_{2i,t} \quad (11)$$

Where $Q_{i,t}$ is Rwandese crop *i* 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*. $RX_{t-k2}^{e}$ is the expected rate that is predicted for traders time *t* during *t-k2* period as generated in equation (9), $h_{i,t-k3}^{e}$ is the analogous estimates of the expected monthly exchange rate volatility as predicted by traders in equation (10) and *k1, k2,* and *k3* are optimal lags and leads that were identified using Hendry non-standard method.

The quarterly dummy variable, $D_{k4,t}$, was introduced to control the seasonality effect that is inherent in export plots. $Q_{i,t-k5}^{e}$ is the lagged export volume that was included in the model specification so as to allow for an estimable lag length (*k5)* of the autoregressive persistence in export volumes. The equation error term, $\varepsilon_{2i,t}$, is assumed to hold Gauss-Markov properties. Variables in equation (11) are natural log transformation except $D_{k4,t}$, 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 to avoid reporting spurious results. The Augmented Dickey-Fuller Test (ADF) and the Phillipe Perron (PP) test were used as stationarity tests. The series are differentiated and repeatedly lagged until it becomes stationary. The Augmented Dickey-Fuller (ADF) test is based on *t*-statistics of the coefficient obtained from Ordinary Least Squares (OLS) regressions (Fuller (1976). This study adopted the ADF test because (1) It has the can capture the additional dynamics left out by the DF test (2) It ensures that the error term is white noise through the inclusion of additional lag length (Okoruwa, 2003).

The other method of unit root test is Phillips-Perron (1988).This test is a modification and generalization of DF's procedures. While DF tests assume that the residuals are statistically independent (white noise) with constant variance, Phillips-Perron (PP) tests consider less restriction on the distribution of the disturbance term (Enders, 1995). Phillips-Perron tests undertake non-parametric correction to account for auto-correlation present in higher AR order models. The tests assume that the expected value of the error term is equal to zero, but PP does not require that the error term be serially uncorrelated. The critical values of PP tests are similar to those given for DF tests, and this study applied both methods for accurate results.

The time series are tested for co-integration when they are integrated in the same order. This means that $y_t$ and $x_t$ in the regression equation (12) does not drift too far from each other overtime.

$$y_t = \beta x_t + e_t \tag{12}$$

This indicates the existence of a long-run equilibrium relationship between the time series variables, that is, the series in equation (11) 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 (11). The procedure was critical since variables were not integrated of the same order. This involved modeling equation (11) as an ARDL model. The general ARDL representation was specified as follows:

$$\Delta LnQ_{i,t} = \delta + \sum_{k1=1}^{a} \delta_{1,k1} \Delta \ln\left(IP_{t-k1}\right) + \sum_{k2=1}^{b} \delta_{2,k2} \Delta \ln\left(RX^{e}_{i,t-k2}\right) + \sum_{k3=1}^{c} \delta_{3,k3} \Delta \ln\left(h^{e}_{i,t-k3}\right) + \sum_{k4=4}^{d} \delta_{4,k4} \Delta S_{k4,t} + \sum_{k5=1}^{e} \delta_{5,k5} \Delta \ln\left(Q^{e}_{i,t-k5}\right) + \beta_{1,k1} \ln\left(IP_{t-k1}\right) + \beta_{2,k2} \ln\left(RX^{e}_{i,t-k2}\right) + \beta_{3,k3} \ln\left(h^{e}_{i,t-k3}\right) + \beta_{5,k5} \ln\left(Q^{e}_{i,t-k5}\right) + \varepsilon_{2i,t} \tag{13}$$

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 ( $\beta_{1,k1} = \beta_{2,k2} = \beta_{3,k3} = \beta_{5,k5} = 0$ ). 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 values 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 (14) specifies the ECM.

$$\Delta LnQ_{i,t} = \delta + \sum_{k1=1}^{a}\delta_{1,k1}\Delta\ln\left(IP_{t-k1}\right) + \sum_{k2=1}^{b}\delta_{2,k2}\Delta\ln\left(RX^{e}_{i,t-k2}\right) + \sum_{k3=1}^{c}\delta_{3,k3}\Delta\ln\left(h^{e}_{i,t-k3}\right) + \sum_{k4=4}^{d}\delta_{4,k4}\Delta S_{k4,t} + \sum_{k5=1}^{e}\delta_{5,k5}\Delta\ln\left(Q^{e}_{i,t-k5}\right) + \pi ECM_{t-1} + \varepsilon_{2i,t} \quad (14)$$

Equation (14) presents a description of the variation in $LnQ_{i,t}$ around its long-run trend regarding 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 analyzed using the ECM. The residual in equation (10) indicates the speed of monthly coffee or tea 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.

### 3.4 Variables and expected signs

In this study, the variables considered as independent and dependent have the following contextual meaning and sign.

### 3.4.1 Exports volume

Exports are the dependent variables. The unit of measurement is a metric ton (MT) for both coffee and tea exports. Coffee exports are denoted by CEXP while tea exports are denoted by TEXP. Both exports are expressed in logarithmic form.

### 3.4.2 Exports Prices

Exports prices act as an indicator of the value of one unity in a certain currency and here the export prices is the value of one kilogram in USD (USD/Kg). Coffee exports prices and tea exports price are denoted by CP and TP respectively. Both exports prices are expressed in logarithmic form.

### 3.4.3 Real Effective Exchange Rate

Real Effective Exchange Rate (REER) is an average of basket of foreign currencies while a Nominal Effective Exchange Rate (NEER) is an inverse average of asymptotic trade weight. The former can be seen as general measurement of external competitiveness of the country. The REER is the regulator of the NEER by the means of specific foreign price level. The REER is computed as a product of nominal effective exchange rate and domestic consumer price index divided by foreign consumer price index. The real exchange rate can make the Rwandan exports cheaper and competitive on the world market when is increased and the inverse is also true. The real effective exchange rate (REER) was computed as follows:

$$RX = \sum_{i}^{n} \varepsilon_i \omega_i \tag{18}$$

Where $\omega_i$ is the country i's share of trade with Rwanda and $\varepsilon_i$ is the real effective exchange rate defined as:

$$\varepsilon_i = \xi_i \times \frac{CPI_D}{CPI_F} \tag{19}$$

Where $\xi_i$ is the nominal exchange rate (how much of the trading partner's currency is needed to obtain 1 Rwandan franc, $CPI_D$ is the domestic consumer price index and $CPI_F$ is the consumer price index of the trade partner. Depreciation in real exchange rate (an increase in the level of directly quoted exchange rate) may lead to a rise in exports as a result of relative price effect, thus an expected positive sign (Mpofu, 2016). The forward exchange rate refers to an exchange rate that is quoted and traded at current date but the delivery as well as the payment is done at particular date in the future.

### 3.4.4 Real foreign income

Real foreign income (proxied by importer industrial production) and is used as an indicator of demand for Rwandan exports. Economic theory dictates that the sign to be expected is positive, since an increase in the real income of trading partners should lead to greater volume of exports to those partners.

### 3.4.5 Real exchange rate volatility

Volatility is defined as the level of change in the trading price series over time as measured by the standard deviation of logarithmic return. $h_t$ denotes the measure of real exchange rate volatility it mean that it measures uncertainty/risk associated with exchange rate fluctuations. Trade theory is not clear about the sign it can take, which is the main basis for this empirical research.

### 3.4.6 Seasonality

A dummy variable, S, was also included to represent the seasonality. In agriculture the seasons affect the production of crops and consequently the export.

**Table 2:** Variables to be used in the ARDL Model and their expected signs

| Variables | Description and measurement | Expected sign |
|---|---|---|
| REER | Real effective exchange rate is the trade weighted exchange rate between the Rwandan francs against currencies of major trading partners | + |
| RealFInc | Real foreign income is weighted Industrial Production(IP) of importers of in USD | + |
| TEXP | Tea exports measured in metric ton (MT) | + |
| CEXP | Coffee exports measured in metric ton (MT) | + |
| TP | Value of tea exports in Rwandan Francs | + |
| CP | Value of coffee exports in Rwandan Francs | + |
| ExVol | Expected exchange rate volatility in percentage (Ht) | +,- |
| Seasonality | Dummy variable (on season =1) and (off season=0) | + |

# CHAPTER FOUR
# RESULTS AND DISCUSSION

The chapter is divided into four sections. The first section provides discussions on descriptive statistics of coffee and tea exports in Rwanda. The second one presents results and discussion on the developmental trajectory while the third one presents empirical results on the effect of exchange rate fluctuation on export prices. The last section provides a discussion on the effect of exchange rate and its fluctuation on export volume of coffee and tea. Time series data covered from the year 2001 to 2016, on a monthly basis.

## 4.1 Descriptive statistics

### 4.1.1 Coffee and Tea

Descriptive statistics on coffee and tea during the period of 2001 to 2016 are presented in Table 3. Coffee export volume (CEXP) and tea export volume (TEXP) are expressed in metric tons (MT), while export prices are expressed in United State Dollar (USD), and real effective exchange rate (REER) in Frw/USD. Results reveal that the mean per month of CEXP was 1371.8 MT, priced at USD 2169.1/MT the range of quantity exported was from zero to 4400.0 MT per month valued within a range of zero USD to USD 8880.0/ MT.

An average of 1648.6 MT per month of tea was exported and the average price received was USD 1759.3/MT. The maximum quantity of tea exported was 2800.0 MT per month and the minimum was 310.4 MT at an average price range of USD 665.2/MT to USD 3086.9/ MT per month. The average real effective exchange rate (REER) was 111.53 with minimum and maximum values of 91.36 and 149.79 respectively. Concerning skewness, which is a measure of departure from symmetry, tea exports are leftward skewed with values closer to zero but conversely, coffee export prices, tea export prices and tea export REER are skewed to the right, away from normal distribution.

**Table 3:** Descriptive statistics of coffee and tea export function

| Stats | Mean | Std. | Maximum | Minimum | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| **CEXP (MT)** | 1371.756 | 1073.959 | 4400.000 | 0.000 | 0.648 | 2.471 |
| **CP (USD)** | 2.169 | 1.347 | 8.880 | 0.000 | 0.815 | 5.321 |
| **TEXP (MT)** | 1648.585 | 507.766 | 2800.000 | 310.440 | -0.044 | 2.529 |
| **TP (USD)** | 1.759 | 0.718 | 3.086 | 0.665 | 0.264 | 1.823 |
| **REER** | 111.533 | 10.010 | 149.790 | 91.360 | 0.347 | 3.895 |

## 4.2 Developmental trajectory of coffee and tea

### 4.2.1 Coffee

The results show in Figure 5 that the coffee export was small in 2001 but it increased from 2002 to 2005 due to the preferential trade agreement following the certification of its high value specialty coffee which reached Europe and USA market shelves in 2001. Since 2002, farmers began to realize the value of producing coffee. Thus, cherry prices more than doubled in the following year 2003. The capacity of fully washed cherries also significantly improved so that in 2006, average prices gained by coffee washing stations for their coffee translated to a premium of 5 USD per kg over the New York Coffee price (the standard reference price for coffee worldwide) placing Rwandan fully washed coffee firmly in the fine coffee and specialty price range (MINICOM, 2011).

Coffee has again become one of the country's foremost exports, with receipts growing at an average of 30% per year during period of 2002 to 2006. Along the improved coffee variety, production rates increased by 21.6% due to favorable weather conditions coupled with increased use of fertilizer (Boudreaux, 2008). Prior to the 2006 effect, coffee exports increased from USD 32.2 million to USD 38 million consecutively by value in 2004 and 2005 (World Bank, 2011). The results reveal the decline of coffee export from then until 2016 this is due to the decline in coffee beans prices, where even the Rwandan coffee export revenue dropped by 5.17%, from USD 64.03 million in year 2014 to USD 60.7 millions in year 2015 (NAEB, 2015). The trend analysis of Rwanda coffee exports is shown by Figure 5.

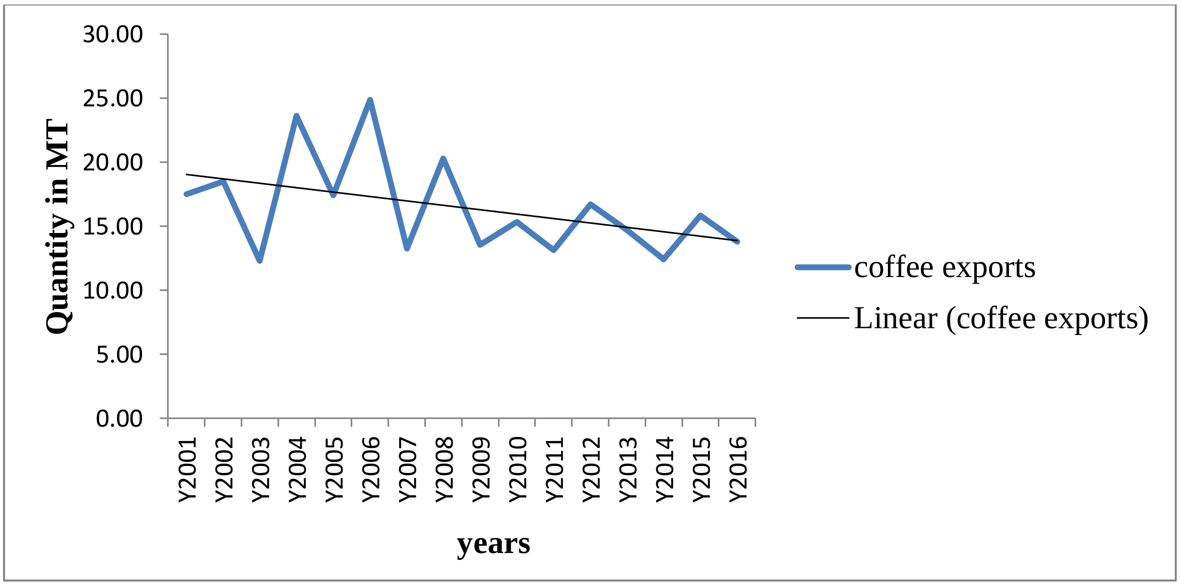



**Figure 5:** Trend of Coffee exports (2001-2016)

The trend analysis of Rwanda coffee exports presented by Figure 5, shows a decline in the growth of coffee exports during the period of 2001-2016. This finding shows that there is a need to reshape the coffee industry and it may be advisable for government to address the issue of low yields, improve operational efficiency of washing stations and improve business environment for coffee exporters.

### 4.2.2 Tea

The results from Figure 6 clearly show that the tea was declining in terms of quantity export from 2001 up to 2004. The reason behind was the low price and lack of clear policy concerning tea export (MINAGRI, 2013). According to the results, the year 2005 was the starting point of the increase in tea export up to 2016.  The main reason was the clear tea export policy. The tea became the main export crop by value in 2009 and 2010, contributing USD 48.2 million and USD 55.7 million respectively to Rwanda export earnings. Over five year's period (2006-2010), a 14% increase in tea exports per year was observed. Increase was due to privatization of factories and the eradication of the tea plant disease which challenged the sector in 2009 (World Bank, 2011).

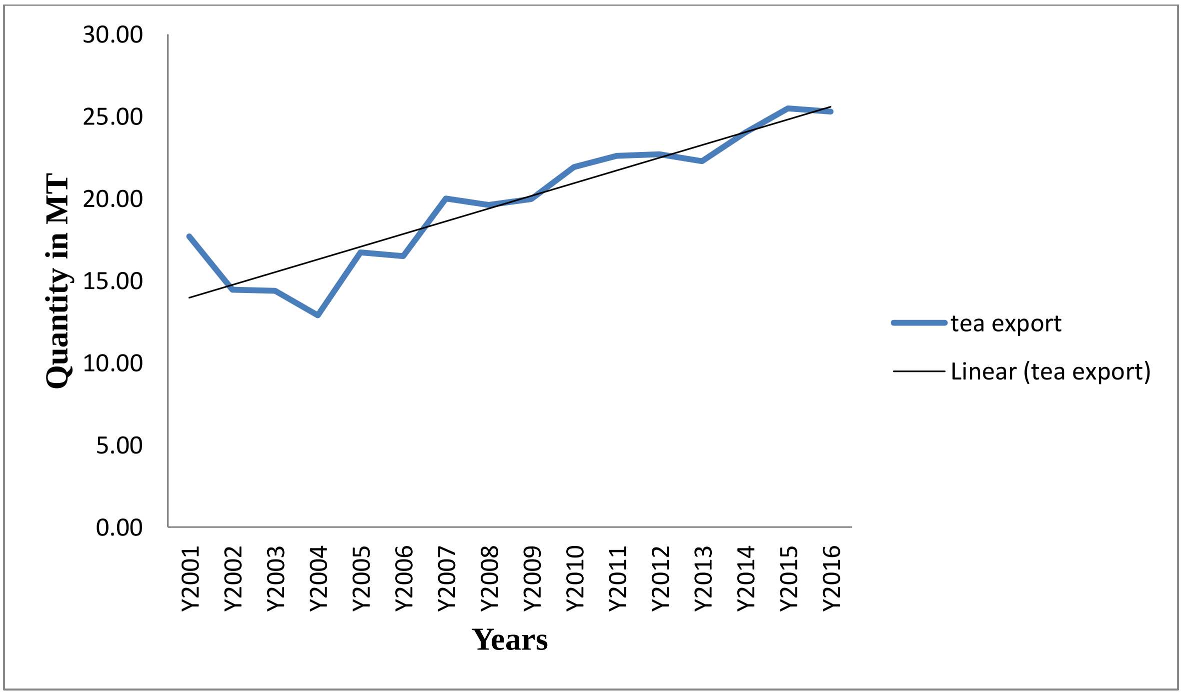



**Figure 6:** Trend of tea exports (2001-2016)

From 2007 up to 2012, there was a continuous increase in the price of exported tea that is attributed to the government's strategy regarding tea which was a two-fold increase in production and improvement of quality. The country has however begun diversifying the different varieties of tea and premium products (Alinda, 2012). Figure 6 reveals that tea exports have generally shown an upward trend from 2001 to 2016, particularly from the period of 2004 up to 2016. The main reason is the country's investment directed towards the tea sector. A new agricultural policy which covers the tea strategy emphasizes on increasing investment, expansion of the area under tea cultivation and quality control.

Regression analysis results of tea exports on time (years) revealed a positive coefficient. The observed coefficient of time implies that tea exports increased at a rate of 0.3 percent per month on average (Table 4). The meaning is that over the period of 2001 to 2016, tea exports exhibited an upward growth. The observed p-value shows that the growth of the exports was significant at 1 percent. The coefficient is however interpreted as the instantaneous growth rate, that is, growth rate at a point in time, a month in this case since the study used monthly data.

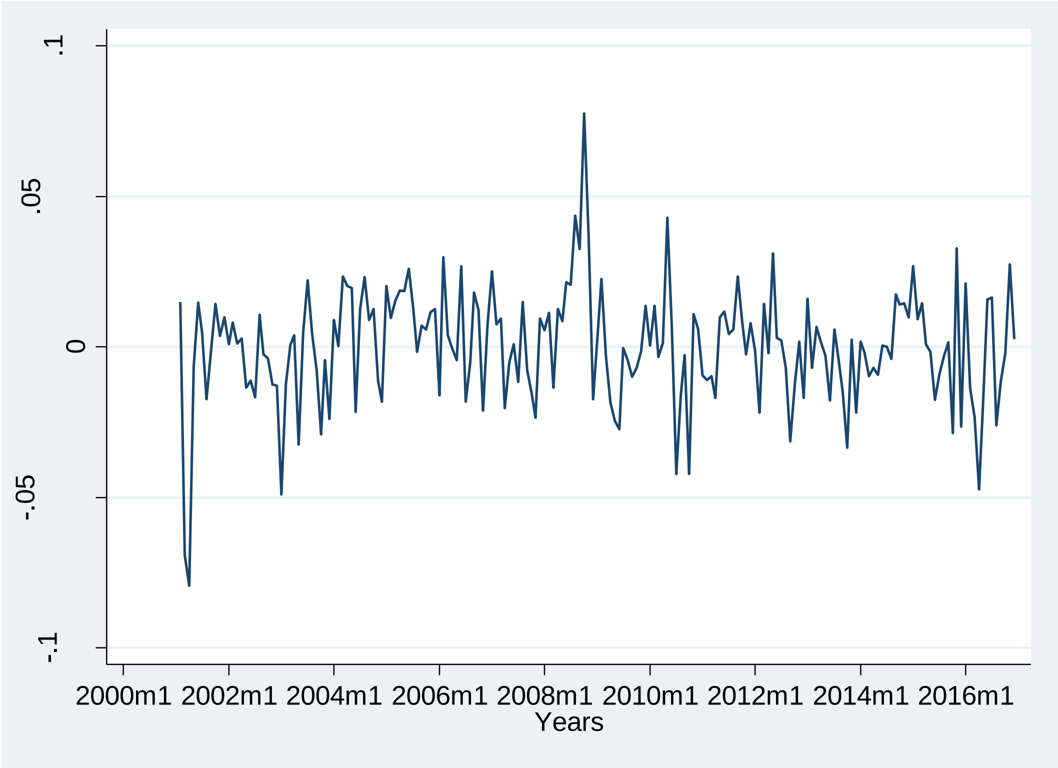
**Table 4:** Regression analysis of tea exports

| Tea Export | Coef. | Std. Err. | *t*-Value | P>\|t\| |
|---|---|---|---|---|
| **Month** | 0.0034 | 0.0004 | 8.3900 | 0.0000 |
| **_Cons** | 12.2891 | 0.2360 | 52.0700 | 0.0000 |

### 4.3 Effect of exchange rate fluctuation on export price

#### 4.3.1 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 7). 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 7:** Clustering effects of exchange rate

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 regarding the existence of arc effects was thus rejected at 1 percent significant level. Auto-Regressive and Integrated Moving Average (ARIMA (p,d,q) was performed. Where p denotes the number of autoregressive terms; d the number of times the series has to be differenced before it becomes stationary and q the number of moving average terms). ARIMA popularly known as Box-Jenkins methodology, was processed for the first difference in the natural logarithm of the real exchange rate (DLRX) series in order to know whether exchange rate follows a purely Auto-Regressive (AR); Moving Average (MA); Auto-Regressive Moving Average (ARMA) or Auto-Regressive and Integrated Moving Average (ARIMA) and if so what is the value of p, d and q.

The ARIMA method is usually made up of 4 steps (identification, estimation, diagnostic checking and forecasting). However, the three steps proposed by Wand *et al*. (2001) were followed in this study. First used was the Box-Jenkins iterative technique to reduce the set of prospective ARIMA specifications. Next, among the resulting candidate ARIMA specifications was screened to eliminate those having a *p*-value for Ljung-Box portmanteau

(Q (12)) statistic less than 0.3, a significant level clearly supporting the assumption of white noise. Finally, from the candidate models having passed the Box-Jenkins and Q (12) screening, the optimal mean specification was chosen based on the Schwarz Bayesian criterion (SBC) similar to Barret (2007). Box-Jenkins methodology established that an AR (1) model best represents the conditional mean of the DLRX series in equation (1). Table 5 reports the estimated parameters and table 6 reported diagnostic tests of exchange rate equations.

**Table 5:** Exchange rate model

| **Models** | **Model1** | | **Model2** | | **Model3** | |
|---|---|---|---|---|---|---|
| | **Coefficient** | **Std.Error** | **Coefficient** | **Std.Error** | **Coefficient** | **Std.Error** |
| **Conditional mean equation** | | | | | | |
| $\gamma_0$ | 0.0006 | 0.0020 | 0.0002 | 0.0016 | 0.0011 | 0.0019 |
| $\gamma_1$ | 0.3431** | 0.1334 | 0.1831 | 0.2640 | 0.2704 | 0.1912 |
| **Conditional variance equation** | | | | | | |
| $\omega_0$ | | | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| $\alpha_1$ | | | 0.1468 | 0.1030 | 0.0022 | 0.0896 |
| $\beta_1$ | | | 0.3939 | 0.4096 | 0.6919 ** | 0.3298 |
| $\eta$ | | | | | 0.1511 | 0.1058 |

**Note**: **, indicate the significance of a two-tailed test at the 0.10, 0.05 and 0.01 significance levels, respectively.

Model 1. AR(1) $DLRX_t = \gamma_0 + \gamma_1 DLRX_{t-k} + \varepsilon_{1,t}$

Model 2. AR(1)- GARCH(1,1) $DLRX_t = \gamma_0 + \gamma_1 DLRX_{t-k} + \varepsilon_{1,t}$

$$h_t = w_0 + \alpha_1 \varepsilon_{1,t-1}^2 + \beta_1 h_{t-1}$$

Model 3. AR(1)-GJR GARCH(1,1) $DLRX_t = \gamma_0 + \gamma_1 DLRX_{t-k} + \varepsilon_{1,t}$

$$h_t = w_0 + \alpha_1 \varepsilon_{1,t-1}^2 + \beta_1 h_{t-1} + \eta S_{t-1} \varepsilon_{1,t-1}^2$$

Where $S_t$ =1, if the exchange rate exhibit negative shock; otherwise.

The Ljung-Box Q-statistic of residuals from the AR (1) process proves insignificant (Q(12)= 8.59, *p*-value=0.73), signaling the absence of residual serial correlation. The squared residuals of the AR (1) process also indicated the absence of correlation ($Q^2$ (12) =11.98, *p*-value=0.44). Then a variety of symmetric GARCH and asymmetric GJR GARCH specifications was tested. The diagnostic statistics for both the GARCH(1,1) and GJR

GARCH(1,1) models indicated no violation of the normality assumption (the *p*-value of the Jarque-Bera statistics were 0.11 and 0.13, respectively).

It also indicated that both models successfully account for both first and second order serial dependence (the *p*-value of the Q(12) statistics were 0.58 and 0.56, respectively, the *p*-value of the $Q^2(12)$ statistics were 0.44 and 0.49, respectively). Although both models (GARCH(1,1) model and GJR-GARCH(1,1) model) fit the exchange rates process adequately, GARCH (1, 1) model was opted because the estimated asymmetry parameter (η) of the GJR GARCH model was not significantly different from zero and, relatively, a likelihood ratio test indicated no significant difference between the GJR GARCH and the symmetric GARCH model (Table 6 ).

**Table 6**: Model diagnostic test

| test | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | **Coefficient** | ***p* -Value** | **Coefficient** | ***p*-Value** | **Coefficient** | ***p*-Value** |
| **Q(12)** | 8.5917 | 0.7374 | 10.3482 | 0.5854 | 10.6225 | 0.5615 |
| **$Q^2$(12)** | 11.9897 | 0.4465 | 12.0008 | 0.4456 | 11.4470 | 0.4910 |
| **Skewness** | 0.5094 | 0.2411 | 0.3195 | 0.1229 | 0.4242 | 0.1474 |
| **kurtosis** | 0.1238 | 0.2411 | 0.0763 | 0.1229 | 0.0766 | 0.1474 |
| **J-bera** | 2.6800 | 0.2600 | 4.4000 | 0.1100 | 4.0600 | 0.1300 |
| **LLH** | 437.8928 | | 439.8420 | | 440.4053 | |
| **LR** | | | | | 1.1300 | |

**Note:** (1) Q and $Q^2$ represent the Ljung-Box test statistics up to 12th order serial correlation for each series.

(2) J-Bera = Jarque-Bera normality test statistic.

(3) LLH represents the log likelihood value.

(4) LR indicates the likelihood ratio test for the null hypothesis of GJR GARCH (1,1) vs. GARCH(1,1)specification.

### 4.3.2 Unit root test of coffee and tea export function variables

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 7. All variables were found to be stationary at the first difference but some were not stationary at level.

**Table 7:** Unit root test of coffee and tea export function variables

| **Variables** | **ADF** | | **PP** | |
|---|---|---|---|---|
| | **Level** | **First difference** | **Level** | **First difference** |
| **Industrial production** | -2.270 | -20.707 [c] | -1.503 | -27.805 [c] |
| **Coffee export** | -9.381 [c] | -19.371 [c] | -9.329 [c] | -21.674 [c] |
| **Tea export** | -5.514 [c] | -13.711 [c] | -5.495 [c] | -14.065 [c] |
| **Coffee export price** | -3.440 | -17.853 [c] | -2.858 | -19.712 [c] |
| **Tea export price** | -2.045 | -21.480 [c] | -1.384 | -24.551 [c] |
| **Exchange rate volatility** | -5.050 [c] | -18.097 [c] | -5.050 [c] | -18.097 [c] |
| **Real effective exchange rate** | -2.370 | -7.075 [c] | -2.370 | -7.075 [c] |

**Note:** [c] 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, coffee and tea prices, 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 exceeds 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 8 indicate that the computed ADF and PP test statistics for tea and 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 coffee export prices, tea export prices, 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 differentiated. Thus, the variables were differentiated of order one I (1) 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.

### 4.3.3 Co-integration among variables that affect coffee prices

The outcomes of the bounds approach for co-integration amongst factors that affect coffee prices are reported in Table 8. The computed F statistic is superior to the F-critical at 10, 5, 2.5 and 1 percent respectively. Consequently, the null hypothesis is rejected for this reason; there exists a long-run relationship amongst the variables.

**Table 8:** F-Bound test for coffee price estimate function

| Test Statistic | Value | Significance level. | I(0) | I(1) |
|---|---|---|---|---|
| **F-Statistic** | 10.04 | 10% | 2.97 | 3.74 |
| **K** | 3 | 5% | 3.38 | 4.23 |
| | | 2.50% | 3.8 | 4.68 |
| | | 1% | 4.3 | 5.23 |

A test of the residuals shows that they are stationary, meaning the existence of co-integration among the variables (Table 9). Given that there is co-integration among the variables, the short-run and long-run dynamics of the factors that affect coffee prices are examined in section 4.3.3.1

**Table 9:** Unit root for coffee price estimate function

| | | *t*-Statistic | Prob.* |
|---|---|---|---|
| **Augmented Dickey Fuller test statistic** | | -13.5657 | 0.0000 |
| **Test critical values:** | 1% level | -3.4712 | |
| | 5% level | -2.8794 | |
| | 10% level | -2.5764 | |

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

#### 4.3.3.1 Estimation of short-run and long-run relationships of coffee export prices function

The ARDL (1, 0, 2, 2), where (1, 0, 2, 2) are the number of lags of CP, IP, REERF and HtF respectively, was used to estimate factors that affect coffee price. The lag structure of the ARDL model was determined by the Akaike Information Criterion (AIC). The model incorporated the trend variable. Factors that affect coffee exports and the matching co-integration equation are shown in Table 10 and 11. The estimation results of long-run coefficients for coffee export price function are reported in Table 10.

Results revealed that income in importing countries proxied by Industrial Production had a significant effect on Rwandan coffee export prices. The elasticity of Rwandan coffee export prices with respect to industrial production was 3.02. This means a 1 percent increase in the amount of industrial production by importing country increases coffee prices by 3.02 percent in the long-run and is significant at 5 percent level of significance. The coefficient of real effective exchange rate is significant in long-run. The partial elasticity of coffee price with respect to real effective exchange rates is 1.95 in long-run. This means that a 1 percent increase in the real effective exchange rate (depreciation of the Rwandan Francs against its trading partner) results in an increase in price by 1.95 percent in the long-run.

The conditional variance (exchange rate fluctuation or shock) was found to have a positive and statistically significant effect on Rwandan prices in long-run. The results show 1 percent increase in conditional variance resulted in 1.5 percent increase in Rwandan coffee export prices in long-run. This means that the exchange rate fluctuation (exchange rate volatility) of Rwandan francs has a positive effect on Rwandan coffee export prices in long-run. This result are consistent with findings by Kantike and Eglite (2013) who found that currency exchange rate fluctuations, are among the most significant factors that affect grain prices in the world. Findings by Hochman *et al.* (2011), shows that exchange rate fluctuation contributed 26 percent to food commodity prices such as corn, soybean, wheat and rice. On the other hand contradict to findings by Zhang and Buongiorno (2010) who found that exchange rate volatility affect export prices negatively, a 1% increase in volatility led to 0.026% decrease in the long-run.

**Table 10:** Long-run coefficients for coffee export price function

| Variable | Coefficient | Std. Error | *t*-Value | Prob |
|---|---|---|---|---|
| **Industrial Production** | 3.0191** | 1.1737 | 2.5722 | 0.0111 |
| **Real Effective Exchange Rate** | 1.9539 | 1.8898 | 1.0339 | 0.3028 |
| **Exchange Rate Volatility** | 1.4539** | 0.6178 | 2.3536 | 0.0199 |
| **@Trend** | 0.0002 | 0.0028 | 0.0794 | 0.9368 |

**Note:** ** means significant at 5% level.

Table 11 reports the estimation results of short-run coefficient for coffee export price. The results show that the probability values of the coefficient of real effective exchange rate regarding the previous period were statistically significant. This means that the depreciation of Rwandan francs against major trading currencies in the previous period have greater effect on Rwandan coffee prices.  A 1 percent increase in the REER of the previous one month resulted in 11.56 percent increase in current Rwandan coffee export prices and was statistically significant at 5 percent. The current findings are inconsistent with the findings of Khaledi *et al*. (2013) who found that the prior period had a negative impact on export prices. On the contrary, Issar and Varma (2016) found no significant effect between price of rice and exchange rate.

The exchange rate volatility (shock or conditional variance) in the previous period (month) was found to have a negative and significant effect on Rwandan coffee export prices. This means that a 1 percentage increase of shock in previous one month resulted in 0.6 percent decrease on current Rwandan coffee exports prices in the short-run. This shows the need for improvement in business environment for coffee exporters by improving the way of contracting in international market as well as domestic ones.

The results show that the season one ($X_1$) has a negative and significant effect on Rwandan coffee export prices, significant at 5 percent level. The partial elasticity of Rwandan coffee export prices with respect to season one was found to be -0.15. This means that in the presence of season one, coffee prices decreased by 15 percent.

**Table 11:** Short-run coefficients for coffee export price function

| variable | Coefficient | Std.Error | *t*-Value | Prob |
|---|---|---|---|---|
| **c** | -41.7804*** | 5.8163 | -2.1834 | 0.0000 |
| **D(REERF)** | -0.9981 | 4.5947 | -0.2172 | 0.8283 |
| **D(REERF(-1))** | 11.5609** | 4.6050 | 2.5105 | 0.0131 |
| **D(HtF)** | -0.2437 | 0.3308 | -0.7367 | 0.4624 |
| **D(HtF(-1))** | -0.6001* | 0.3265 | -1.8382 | 0.0680 |
| **$X_1$** | -0.1495** | 0.0577 | -2.5872 | 0.0106 |
| **$X_2$** | -0.0242 | 0.0579 | 0.4167 | 0.6775 |
| **$X_3$** | 0.0483 | 0.0552 | 0.8756 | 0.3827 |
| **CointEq(-1)*** | -0.4483*** | 0.0624 | -7.1785 | 0.0000 |
| R-squared | | | | 0.7432 |
| Prob (F-statistic) | | | | 0.0000 |
| Breusch-Godfrey LM Test (Prob>. Chi-Square) | | | | 0.3164 |
| Breusch-Pagan-Godfrey (Prob>. Chi-Square) | | | | 0.2216 |
| Ramsey RESET Test(Prob F) | | | | 0.1739 |
| Jarque-Bera ( Prob) | | | | 0.0000 |

*(on variable name) *P*-value incompatible with t-bounds distribution

**Note:** *, **, *** (on variable numbers) means significant at 10, 5 and 1 percent respectively.

The error correction term is negative and significant thereby affirming the existence of co-integration among the variables. The coefficient of the error correction term implies that 44.83 percent of the disequilibrium is corrected within a month, as the frequency of the data is monthly. Since the error correction term is significant and large, the speed of adjustment towards the long-run equilibrium is therefore high. The reported R squared implies that the variables in the estimated model explained 74.32 percent of the variation in coffee prices.

#### 4.3.3.2 Post-estimation diagnostic tests for factors affecting coffee prices

The results on autocorrelation are presented lower part of Table 11. The test for autocorrelation was necessary since the estimated parameters may be inefficient thus the standard errors may be wrongly estimated and biased downwards (Dougherty, 2001). The Breusch-Godfrey serial correlation lagrange multiplier (LM) test was used to test the null hypothesis of no autocorrelation against the alternative hypothesis of autocorrelation. The computed probability value statistic was 0.3164 implying that the null hypothesis is not rejected; hence the estimated model is free from autocorrelation. The results of the Breusch-Pagan-Godfrey test for heteroskedasticity like estimation in the presence of autocorrelation, the estimated parameters in the presence of heteroskedasticity were inefficient and had high standard errors thereby rendering the F and t-value invalid.

The null hypothesis is that the disturbance term is homoskedastic while the alternative hypothesis is that the error term is heteroskedastic. Under the Breusch-Pagan–Godfrey test, the probability value was found to be 0.2216 implying that the null hypothesis cannot be rejected; hence the disturbance term is homoskedastic. The Jarque-Bera test was used to check if the residuals are normally distributed. The null hypothesis of the residuals being normally distributed was tested against the alternative hypothesis of the residuals not being normally distributed. The probability value of the computed Jarque-Bera test statistic was found to be zero implying null hypothesis is rejected; hence the residuals are not normally distributed. The Ramsey-Reset test was also used to test if the estimated model is correctly specified in terms of omission of relevant variables, inclusion of irrelevant variables as well as the functional form. The null hypothesis is that the model is stable while the alternative hypothesis is that the model is unstable. The probability value was found to be 0.7406 implying that the null hypothesis is not rejected. Results of the Ramsey- Reset test are presented in Table 11.

The Cumulative Sum of Recursive Residuals (CUSUM) (Figure 8) and Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) (Figure 9) 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 in the Figure 8 and Figure

9 shows that the coefficients are stable as the recursive residuals lay within the 5 percent level of significance; hence the null hypothesis is not rejected. Therefore, the estimated coefficients are stable and consistent.

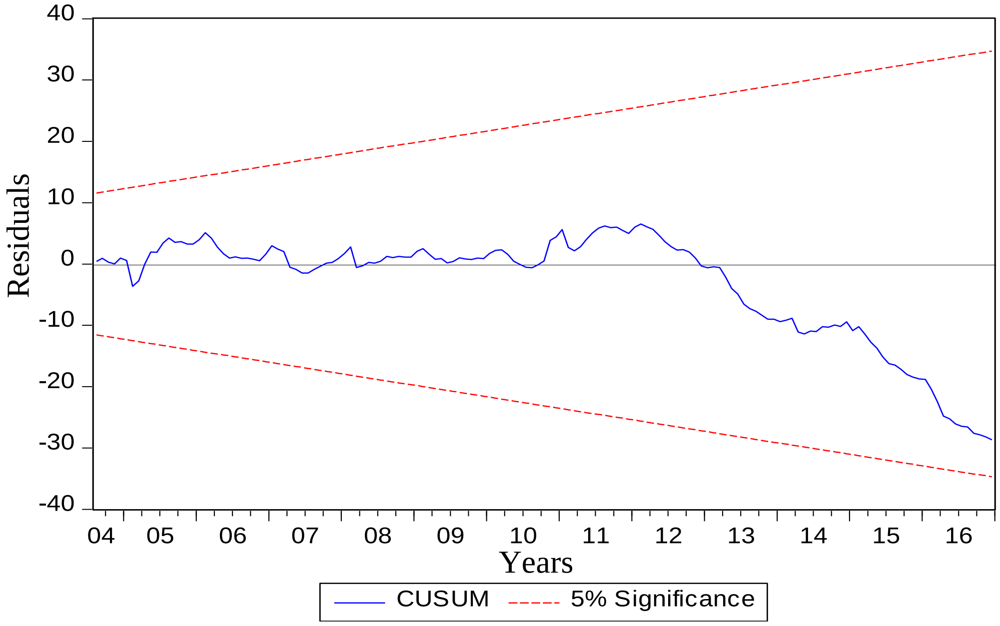



**Figure 8:** Cumulative sum of recursive residuals for coffee prices function

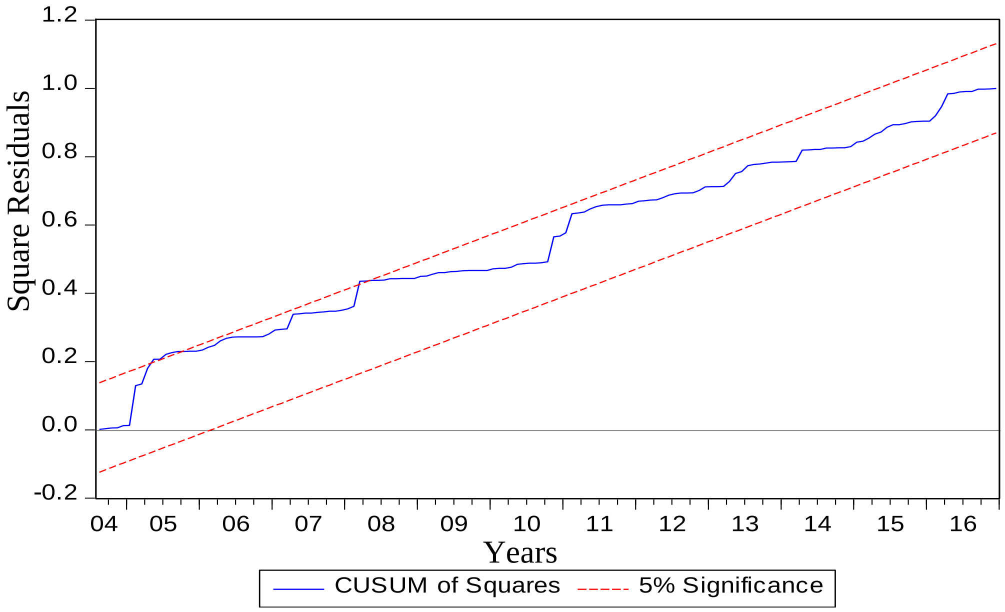



**Figure 9:** Cumulative sum of square of recursive residuals for coffee prices function

### 4.3.4 Co-integration among variables that affect tea exports prices

Results of the ARDL bounds test are shown in Table 12. The null hypothesis is that there is a long-run equilibrium relationship among the variables while the alternative hypothesis is that there is no co-integration among the variables. The computed F-statistic is laying between I

(0) and I (1) at 5 percent level of significance implying that the null hypothesis is rejected; hence there is existence of a long-run equilibrium relationship among the variables.

**Table 12:** F-Bound Test for tea price estimate function

| Test Statistic | Value | Significance level | I(0) | I(1) |
|---|---|---|---|---|
| **F-Statistic** | 4.11 | 10% | 2.97 | 3.74 |
| **K** | 3 | 5% | 3.38 | 4.23 |
| | | 2.50% | 3.8 | 4.68 |
| | | 1% | 4.3 | 5.23 |

A unit root test on the residuals also confirms the existence of co-integration among the variables (Table 13). The absolute value of computed *t*-statistic is superior to the test critical value at 10, 5 and 1 percent respectively, implying the rejection of null hypothesis (not stationary). Given that there is co-integration among the variables, the short-run and long-run dynamics of the factors that affect coffee prices are examined in section 4.3.4.1

**Table 13:** Unit root for tea price estimate function

| | | *t*-Statistic | Prob.* |
|---|---|---|---|
| **Augmented Dickey Fuller test statistic** | | -11.4864 | 0.0000 |
| **Test critical values:** | 1% level | -3.4712 | |
| | 5% level | -2.8794 | |
| | 10% level | -2.5764 | |

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

**4.3.4.1 Estimation of short-run and long-run relationships of tea export prices function**

The existence of co-integration among the variables suggests that the short-run and long-run dynamics of factors that affect tea exports prices can be examined. The lag selection of the estimated short and long-run ARDL (24, 24, 23, 23), where (24, 24, 23, 23) are the number of lags of tea price (TP), industrial production (IP), real effective exchange rate (REERF) and exchange rate volatility (HtF) respectively, was determined by the Akaike Information Criterion. The long-run and short-run dynamics of factors that affect tea exports prices are presented in Tables 14 and 15. The detailed of estemated short-run model are shown in appendix A. The estimated results of long-run coefficients for tea export price function are shown in Table 14.

The results of the long-run dynamics are consistent with economic theory and have the correct signs tea exports prices are elastic to the real effective exchange rates in long-run. An increase by 1 percent in the Rwandan francs price of the currencies of the trading partners or a depreciation increases tea exports prices by 10.79 percent in the long-run. This result is consistent with findings by Khaledi *et al*. (2016), who found that the change in exchange rate in long-term was one of the most important factor that affecting export prices of dates. Jumah and Kunst (2001) found that dollar/sterling exchange rate volatility on futures markets for coffee and cocoa was the main source of risk for the commodity futures price. However, the current results are not consistent with the ones of Brun *et al*. (2015) who found that there was no statistical significant influence of the exchange rate over the physical prices of soybean.

**Table 14:** Long-run coefficients for tea export price function

| Variable | Coefficient | Std. Error | *t*-Value | Prob |
|---|---|---|---|---|
| **Industrial Production** | -2.7834 | 2.1305 | -1.3064 | 0.1991 |
| **Real Effective Exchange Rate** | 10.7917** | 4.9325 | 2.1879 | 0.0347 |
| **Exchange Rate Fluctuation** | -1.4169 | 1.3382 | -1.0589 | 0.2962 |
| **Trend** | 0.0093** | 0.0035 | 2.6874 | 0.0105 |

**Note:** ** means significant at 5 percent.

The estimated results of short-run coefficients for tea export price function are shown in Table 15. The results of the short-run dynamics are consistent with economic theory and have the correct signs. The previous month's prices have a negative and significant effect on the current prices in short-run. The coefficient of the lagged prices imply that a 1 percent increase in the export prices results in the previous one month leads to a reduction in the current prices of tea exports by 0.41 percent in short-run. This may be due to previous performance on the international market.

The coefficient of exchange rate volatility (conditional variance or shock) is negative and significant in the short-run. The partial elasticity of tea prices with respect to conditional variance is -0.2947 in the short-run. This means 1 percentage increase in conditional variance result in a decline by 0.2947 percent in the current Rwandan tea exports prices in the short-run. This means that a shock has a negative effect in short-run. This result is consistent with that found by Zhang and Buongiorno (2010) who found that exchange rate volatility affect export prices negatively. The results are also in agreement with Kantike and Eglite (2013) who found that the currency exchange rate fluctuations was among the most significant factors that affect grain prices in the world. Hochman *et al.* (2014) noted that exchange rate fluctuation influenced positively food commodity prices movements such as corn, soybean, wheat and rice prices.

**Table 15:** Short-run coefficients for tea export price function

| Variable | Coefficient | Std.error | *t*-Value | Prob |
|---|---|---|---|---|
| **C** | 11.5840 | 2.4277 | 4.7716 | 0.0000 |
| **D(TP(-1))** | -0.4093*** | 0.1263 | -3.2422 | 0.0024 |
| **D(IP)** | -0.1952 | 0.5083 | -0.3838 | 0.7031 |
| **D(EXRATEF)** | 2.4794 | 2.4135 | 1.0273 | 0.3106 |
| **D(HtF)** | -0.2947* | 0.1725 | -1.7087 | 0.0954 |
| **$X_1$** | 0.0779 | 0.0529 | 1.4728 | 0.1488 |
| **$X_2$** | 0.0298 | 0.0250 | 1.1902 | 0.2411 |
| **$X_3$** | 0.0177 | 0.0549 | 0.3229 | 0.7484 |
| **CointEg (-1)*** | -0.4333*** | 0.0910 | -4.7612 | 0.0000 |
| R-squared | | | | 0.9898 |
| Prob (F-statistic) | | | | 0.0000 |
| Breusch-Godfrey LM Test (Prob>. Chi-Square) | | | | 0.7964 |
| Breusch-Pagan-Godfrey (Prob>. Chi-Square) | | | | 0.6772 |
| Ramsey RESET Test (Prob F) | | | | 0.2124 |
| Jarque-Bera ( Prob) | | | | 0.0001 |

**Note:** *, **, *** means significant at 10, 5 and 1 percent respectively.

The error correction term is negative and significant thereby confirming the existence of a co-integrating relationship among the variables (Table 15). The coefficient of the error term is moderate thus reflecting a moderate adjustment towards the long-run equilibrium in case of disequilibrium. Forty three percent of the disequilibrium is corrected within one month. The reported R squared implies that the variables in the estimated model explain 99 percent of the variation in tea prices.

#### 4.3.4.2 Post-estimation diagnostic tests for factors affecting tea prices

Results of the Breusch–Godfrey serial correlation test are presented in Table 15. The null hypothesis of no serial correlation was tested against the alternative hypothesis of the existence of the serial correlation. Two lags were used to check for the presence of autocorrelation in the Breusch–Godfrey serial correlation test. The null hypothesis fails to be accepted if the probability value of the calculated chi-square statistic is less than 0.05. The probability value of the computed chi-square statistic was not significant at 5 percent level of significance (0.79). Therefore, the null hypothesis was not rejected implying that the residuals were not serially correlated.

The Breusch–Pagan–Godfrey Heteroskedasticity test was used to test the residuals regarding whether they are homoskedastic or not, the null hypothesis being a homoskedastic disturbance term against the alternative hypothesis of heteroskedastic disturbance term. Rejection or acceptance of the null hypothesis depends on the significance of the computed chi-square statistic at 5 percent level of significance. The results of the Breusch–Pagan–Godfrey Heteroskedasticity test are presented in Table 15. The probability value of the computed chi-square statistic is more than 5 percent level of significance. Therefore, the null hypothesis fails to be rejected implying that the residuals are homoskedastic. Normality of the residuals was tested by the Jarque-Bera normality test. The residuals are normally distributed is the null hypothesis while the residuals are not normally distributed is the alternative hypothesis. The results of the Jarque-Bera normality test are presented in table 15. The probability value of the Jarque-Bera test is significant at 1 percent level of significance. Therefore, the null hypothesis is rejected; hence the residuals are not normally distributed.

The Ramsey–reset test was used to test if the estimated ARDL (24, 24, 23, 23) is stable and correctly specified, the null hypothesis being the model is correctly specified against the alternative hypothesis that the model is mis-specified. The results of the Ramsey-reset test are presented in Table 15. The probability value of the F-statistic is insignificant. Therefore, the null hypothesis is not rejected implying that the model is correctly specified.

A plot of the Cumulative Sum of Recursive Residuals (CUSUM) (Figure 10) and Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) (Figure 11) show that the coefficients are stable as the recursive residuals lie within the 5 percent level of significance. Hence, the null hypothesis fails to be rejected since the coefficients are stable and consistent.

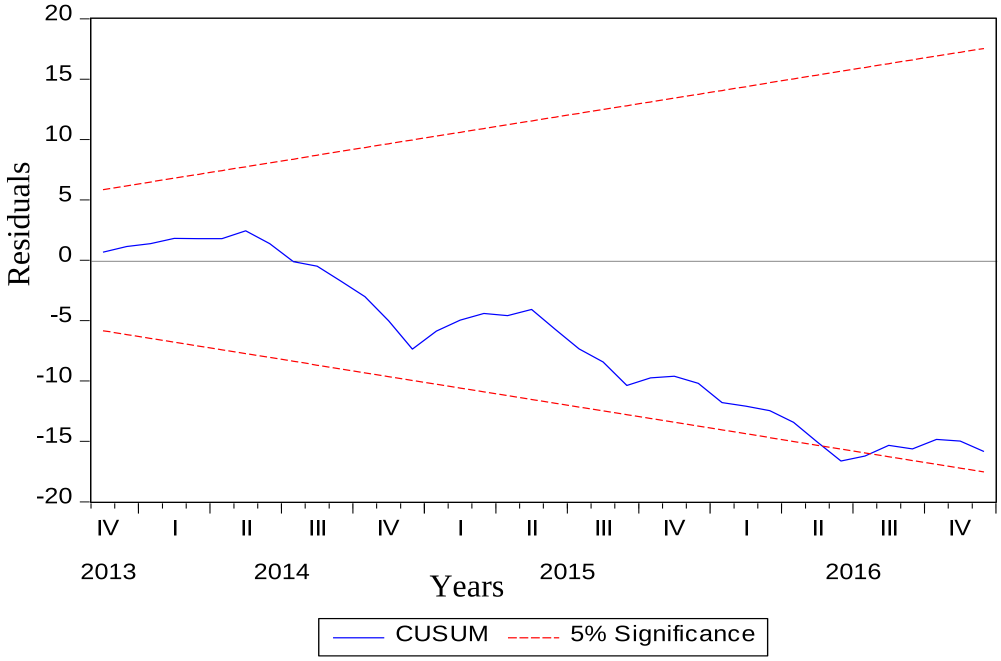



**Figure 10:** Cumulative sum of recursive residuals for tea prices function

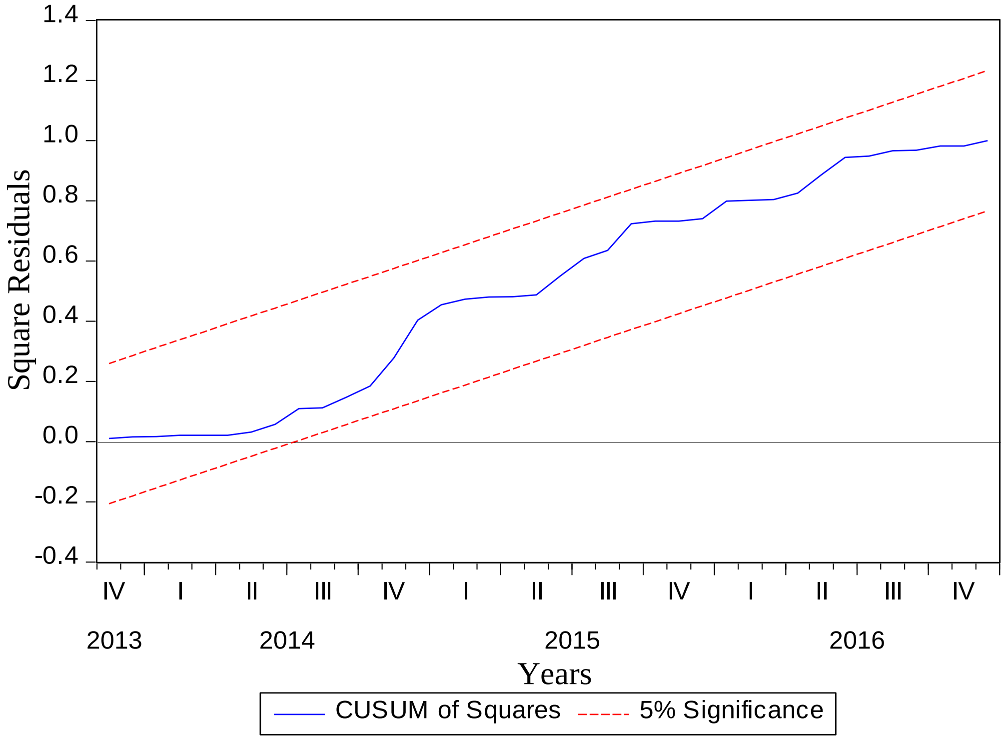



**Figure 11:** Cumulative sum of square of recursive residuals for tea prices function

## 4.4 Effect of exchange rate fluctuation on export volume of coffee and tea

### 4.4.1 Co-integration among variables that affect coffee exports

Table 16 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 between the variables.

**Table 16:** F-Bound Test for coffee export estimate function

| Test Statistic | Value | Significance level | I(0) | I(1) |
|---|---|---|---|---|
| **F-Statistic** | 10.27 | 10% | 2.97 | 3.74 |
| **K** | 3 | 5% | 3.38 | 4.23 |
| | | 2.50% | 3.8 | 4.68 |
| | | 1% | 4.3 | 5.23 |

A test of the residuals shows that they are stationary. This indicates that the variables are co-integrated (Table 17). Section 4.4.1.1 presents the dynamic short-run and long-run relationship between coffee exports and the explanatory variables.

**Table 17:** Unit root for coffee export estimate function

| | | ***t*-Statistic** | **Prob.*** |
|---|---|---|---|
| **Augmented Dickey Fuller test statistic** | | -12.2769 | 0.0000 |
| **Test critical values:** | 1% level | -3.4712 | |
| | 5% level | -2.8794 | |
| | 10% level | -2.5764 | |

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

#### 4.4.1.1 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, REEF 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 18 and 19. Table 18 presents the long-run coefficient estimates for the export function. The results indicate that industrial production of the importing country had a significant and positive long-run influence on coffee export volumes.

A one percent increases 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 adequate adjustment in the importation of coffee when incomes increase such that an increase in revenues 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 number of coffee imports from Rwanda. This 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 18:** Long-run coefficients for coffee export function

| Variable | Coefficient | Std. Error | *t*-value | Prob |
|---|---|---|---|---|
| **Industrial Production** | 26.9389*** | 3.4605 | 7.7846 | 0.0000 |
| **Real Effective Exchange Rate** | 7.4052 | 5.6321 | 1.3148 | 0.1942 |
| **Exchange Rate Fluctuation** | -44.4491*** | 1.5924 | -2.7939 | 0.0072 |
| **@Trend** | -0.0555*** | 0.0059 | -9.3247 | 0.0000 |

**Note:** *** means significant at 1 percent.

Exchange rate volatility was negative and significantly associated with the long-run elasticity of Rwandan coffee exports. A one percent 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 19 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 percent 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 preceding months in short-run. This may be due to earlier performance on the international market. If a nation exported more in the prior months and gained profit, then it increases the volume of exports in the current period.

**Table 19:** Short-run coefficients for coffee export function

| **Variable** | **Coefficient** | **Std.error** | ***t*-Value** | **Prob** |
|---|---|---|---|---|
| **C** | -4921.3950*** | 662.3719 | -7.4299 | 0.0000 |
| **D(CEXP(-1))** | 5.1422*** | 0.8029 | 6.4044 | 0.0000 |
| **D(IP)** | 38.4758* | 18.1127 | 2.1242 | 0.0383 |
| **D(XRATEF)** | 42.2534 | 80.7635 | 0.5232 | 0.6030 |
| **D(HtF)** | -3.8183 | 5.8211 | -0.6559 | 0.5147 |
| **$X_1$** | -1.1727 | 2.4842 | -0.4720 | 0.6388 |
| **$X_2$** | 0.5893 | 2.3618 | 0.2495 | 0.8039 |
| **$X_3$** | 4.7946* | 2.6735 | 1.7934 | 0.0786 |
| **CointEq (-1)*** | -6.3960*** | 0.8607 | -7.4309 | 0.0000 |
| 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 |

**Note:** *, **, *** means significant at 10, 5 and 1 percent respectively.

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.

The previous period (months) exchange rate fluctuation (shock) was positive and statistically significant in the short-run, which means it had substantial influence concerning same previous months, on coffee export volumes. In other words, 1% increase in exchange rate shock in the prior month increases coffee exports. That is, an increase in the previous 2, 3, 4, 5, 6, 7, 8, 10, 11, 12 and 13 months of shocks increases the current coffee exports volume by 32.75, 28.71, 24.23, 25.01, 37.31, 26.50, 23.18, 14.23, 17.52, 20.27, 21.47 and 16.41 percent respectively (appendix B).

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. Also, the dependency on imported intermediate inputs cause 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 once-a-month because the frequency of the data is monthly. Also, the enormous and significant error correction term suggests a high speed of adjustment towards the long-run equilibrium. The reported R-squared implies that the variables in the estimated model explain 74% of the variation in coffee exports.

#### 4.4.1.2 Post-estimation diagnostic tests for factors affecting coffee exports

Tables 20 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 19). The result implies that 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 defined; that is, neither relevant variables were omitted, nor irrelevant variables were included in the model. The Cumulative Sum of Recursive Residuals (CUSUM) (Figure 13) and Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) (Figure 14) were also used to confirm the stability of the coefficients with the null hypothesis that is the coefficients are stable against the alternative hypothesis that is 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.

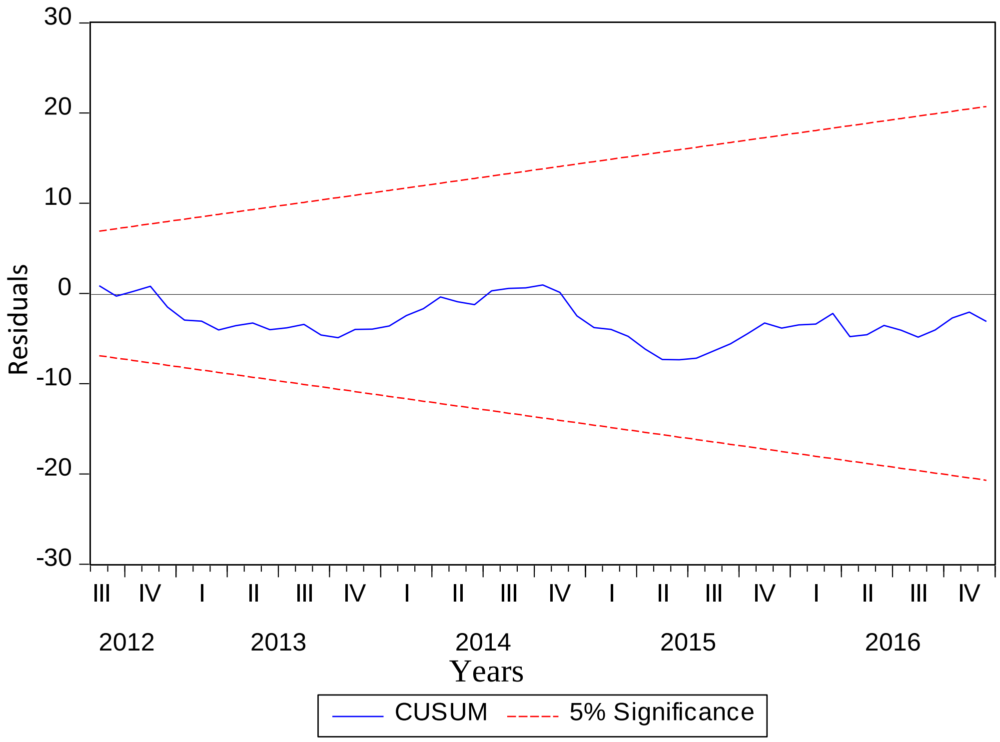



**Figure 12:** Cumulative sum of recursive residuals for coffee export function

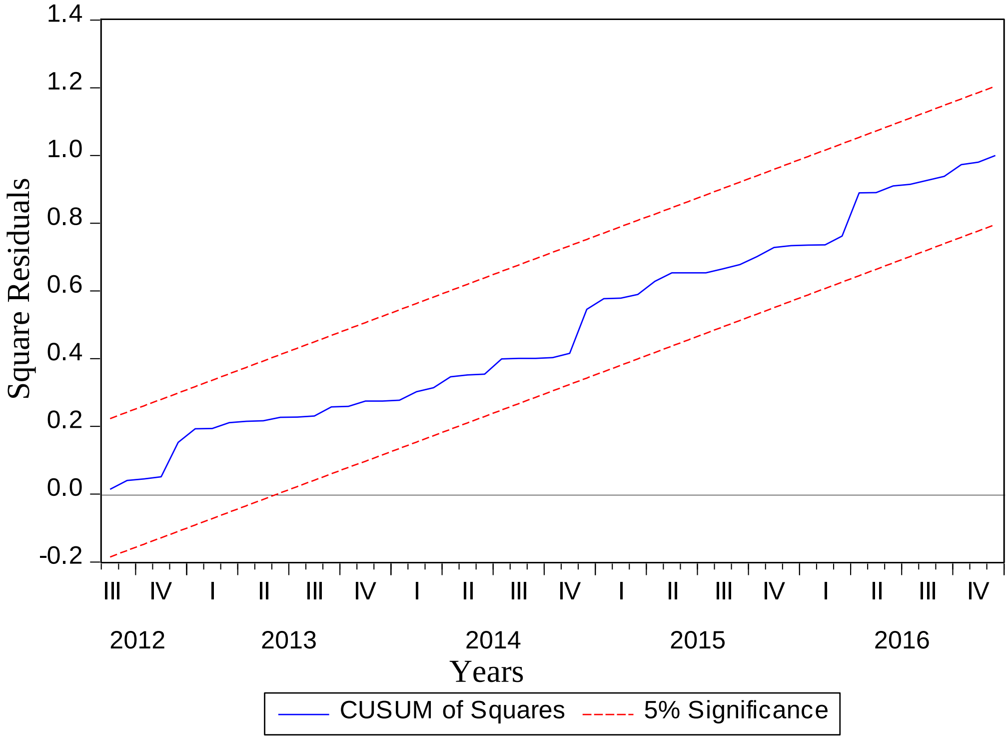



**Figure 13:** Cumulative sum of square of recursive residuals for coffee export function

#### 4.4.2 Co-integration among variables that affect tea exports

The ARDL bounds test results are shown in Table 20. The ARDL bounds test null hypothesis state that there exists a long-run equilibrium relationship (co-integration) among variables. The computed F-statistic was significant at 5% significance level. This implies the null hypothesis for the existence of co-integration was rejected, suggesting that there was a long-run equilibrium relationship between variables.

**Table 20:** F-Bound Test for tea export estimate function

| Test Statistic | Value | Significance level | I(0) | I(1) |
|---|---|---|---|---|
| **F-Statistic** | 9.72 | 10% | 2.97 | 3.74 |
| **K** | 3 | 5% | 3.38 | 4.23 |
| | | 2.50% | 3.8 | 4.68 |
| | | 1% | 4.3 | 5.23 |

Results of a unit root test are presented in Table 21. The results reveal the presence of stationarity. Consequently, the test confirms that the variables are co-integrated. Given that the variables are co-integrated, the short-run and long-run dynamic effects of some factors that affect tea export volumes have to be examined. Section 4.4.2.1 presents the short-run and long-run estimates of the factors that affect tea export volumes.

**Table 21:** Unit root for tea export estimate function

| | | *t*-Statistic | Prob.* |
|---|---|---|---|
| **Augmented Dickey Fuller test statistic** | | -13.7192 | 0.0000 |
| **Test critical values:** | 1% level | -3.4712 | |
| | 5% level | -2.8794 | |
| | 10% level | -2.5764 | |

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

#### 4.4.2.1 Estimation of short-run and long-run relationships of tea export function

The co-integration of the variables suggests the importance of estimating their resultant dynamic effects on the short-run and long-run tea export volumes. The Akaike Information Criterion was used to define the lag selection of the estimated short and long-run ARDL (4, 4, 0, 0). The 4, 4, 0, and 0 are the number of lags of TEXP, IP, REEF and HTF respectively. The results of the Akaike Information Criterion for short and long-run effects of the variables on tea exports are presented in Table 22 and Table 23 respectively.

Table 22 reports the estimation results of long-run coefficients for tea export function. Results show that the long-run export elasticity concerning the income of the trading partner is 1.15. A 1% increase in industrial production of the trading partner resulted in 1.15% increase in tea exports in the long-run. Goudarzi et al. (2012) reported similar results in a study that estimated the effect of industrial production on Iranian pistachio export volumes. Contrastingly, Ragoobur and Emamdy established a negative association between foreign income and Mauritius exports. Moreover, 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.

Tea exports are elastic to the real effective exchange rates. An increase in the Rwandan franc's exchange rate against the currencies of the trading partners or a depreciation increases tea exports by 1.48% in the long-run. Similarly, Fedoseeva (2016) found that, in the long-run, exchange rate changes influenced tea export volumes asymmetrically. Relative to the depreciation of the Euro that is usually beneficial to the European agri-food exports, the appreciation of the Euro was less harmful to exportation the Rwandese tea. The current finding is consistent with results by Anagaw and Demissie (2012) who established a positive and significant influence of exchange rate on Ethiopian exports. Contrary to the current result, Menji (2013) found that the real effective exchange rates had an insignificant impact on Ethiopian merchandise exports. Agasha (2009) also indicated that the real effective exchange rate had a negative and significant relationship with the Ugandan coffee exports.

**Table 22:** Long-run coefficients for tea export function

| Variable | Coefficient | Std. Error | *t*-Value | Prob |
|---|---|---|---|---|
| **Industrial Production** | 1.1506** | 0.4815 | 2.3899 | 0.0181 |
| **Real Effective Exchange Rate** | 1.4786** | 0.6369 | 2.3214 | 0.0216 |
| **Exchange Rate Fluctuation** | 0.2975 | 0.1863 | 1.5964 | 0.1125 |
| **Trend** | 0.0009 | 0.0011 | 0.7691 | 0.4430 |

**Note:** ** means significant at 5 percent.

The short-run estimates from the tea export function are presented in Table 23. The results are consistent with the economic theory and have the expected signs. The previous month's export volume was significantly encouraging in influencing the current level of tea exports. The coefficient indicates that a 1% increase in the previous month's tea export volumes resulted in augmentation in the current volume of tea exports by 0.19% and 0.29% one and three preceding months, respectively, in the short-run. This may be due to prior performance on the international market. If a nation exported more in previous months and gained profit, then the current period's export volumes increase.

The real income (industrial production) of the trading partner positively impacted on both short and long-run tea export volumes. The reason for the reported positive coefficient is that as the economies of the trading partner grow, they may channel their resources towards processing of the same commodity. This may lead to more processed tea activities than production, leading to increased importation of tea. The short-run export elasticity concerning the income of the trading partner was 1.11%, implying that 1% increase in the income of the trading partner results in 1.11% increase in tea exports. Ragoobur and Emamdy (2011) reported similar results by indicating that industrial production of the trading partner positively influenced Mauritius export volumes in the short-run. The previous three months of IP was found to have an adverse short-run effect on the current tea export volume. This means that a 1% increase in IP from the previous three months leads to a decline in tea export volume by 0.93 percent.

**Table 23:** Short-run coefficients for tea export function

| Variable | Coefficient | Std.error | *t*-Value | Prob |
|---|---|---|---|---|
| **c** | -20.3252*** | 2.9148 | -6.9732 | 0.0000 |
| **D(TEXP(-1))** | 0.1940* | 0.1047 | 1.8526 | 0.0659 |
| **D(TEXP(-2))** | 0.1287 | 0.0858 | 1.4989 | 0.1360 |
| **D(TEXP(-3))** | 0.2971*** | 0.0716 | 4.1488 | 0.0001 |
| **D(IP)** | 1.1076** | 0.4284 | 2.5857 | 0.0107 |
| **D(IP(-1))** | -0.1560 | 0.5351 | -0.2916 | 0.7710 |
| **D(IP(-2))** | 0.5843 | 0.5305 | 1.1015 | 0.2725 |
| **D(IP(-3))** | -0.9261* | 0.5039 | -1.8379 | 0.0681 |
| $\mathbf{X_1}$ | -0.0204 | 0.0617 | -0.3307 | 0.7413 |
| $\mathbf{X_2}$ | 0.0979* | 0.0587 | 1.6685 | 0.0973 |
| $\mathbf{X_3}$ | -0.2976*** | 0.0603 | -4.9344 | 0.0000 |
| **CointEq (-1)*** | -0.8138*** | 0.1152 | -7.0634 | 0.0000 |
| R-squared | | | | 0.7865 |
| Prob (F-statistic) | | | | 0.0000 |
| Breusch-Godfrey LM Test (Prob>. Chi-Square) | | | | 0.1459 |
| Breusch-Pagan-Godfrey (Prob>. Chi-Square) | | | | 0.0636 |
| Ramsey RESET Test (Prob F) | | | | 0.1895 |
| Jarque-Bera ( Prob) | | | | 0.3904 |

**Note:** *, **, *** means significant at 10, 5 and 1 percent respectively.

Seasons two and three had positive and negative short-run effect on the current tea exports respectively. This means that during season two, the volume of tea exports rose by 9.79%. Regarding season three, the results imply a decline in tea export by 29.76 percent. The error correction term is negative and significant which affirms that the variables are co-integrated. The error term coefficient is high reflecting a faster speed of adjustment from disequilibrium to a long-run equilibrium. This implies that 81.38 percent of the disequilibrium is corrected within one month. The reported R squared indicates that the variables in the estimated model explain 78.64 percent of the variation in tea exports.

#### 4.4.2.2 Post-estimation diagnostic tests for factors affecting growth of tea exports

Table 24 presents the Breusch–Godfrey test results of the serial correlation. The procedure tested the null hypothesis that the model is free of serial correlation using two lags. If the probability value of the chi-statistic is less 0.5, then the null hypothesis is rejected. The p-value was 0.1459 and insignificant at 5% significance level, implying that the null hypothesis is not rejected. This indicates that the model did not suffer from serial correlation. The Breusch–Pagan–Godfrey heteroscedasticity test was used to test the homoscedasticity of residuals hypothesis. The results of the Breusch–Pagan–Godfrey heteroscedasticity test are presented in Table 23. The probability value of the computed chi-square statistic was 0.0636% at 5% significance level, implying that the null hypothesis of homoscedastic residuals is not rejected.

The Jarque-Bera normality test was implemented to test the normality of residuals. The probability value of the Jarque-Bera test was insignificant at 1% significance level (Table 23). Thus, the normality of residuals hypothesis is not rejected, and a conclusion made that the residuals are normally distributed. Model specification diagnosis was performed using the Ramsey–reset test. The results in Table 23 indicate that the p-value of the F-statistic is 0.18 which is insignificant, showing that the model was correctly specified. A plot of the Cumulative Sum of Recursive Residuals (CUSUM) and the Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) are shown in figures 14 and 15. The results show that the recursive residuals lie within the 5% significance level, meaning that the residuals are stable and consistent.

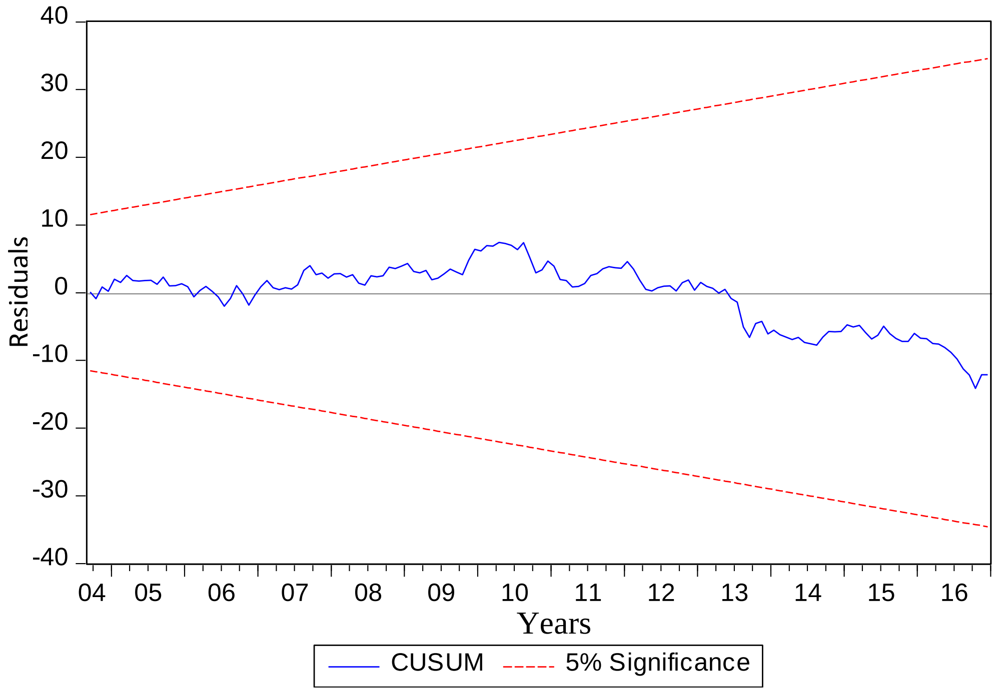



**Figure 14**: Cumulative sum of recursive residuals for tea export function.

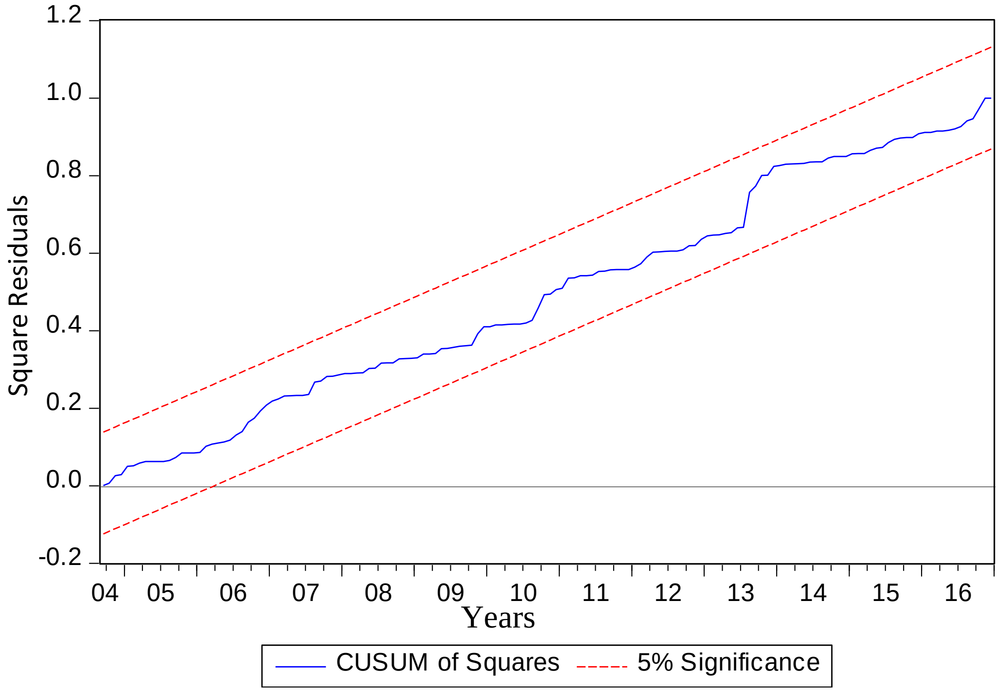



**Figure 15**: Cumulative sum of square of recursive residuals for tea export function

# CHAPTER FIVE
# CONCLUSION AND RECOMMENDATIONS

This chapter provides the conclusion of the study and some policy recommendations which need to be applied to increase the agricultural exports efficiency level. A section for suggestions for further study is also given.

## 5.1 Conclusion

1. Trend analysis for coffee revealed a declining trend per month on average of coffee export. Where the first five years from 2001 the coffee export was important but from 2006 up to 2016 the coffee export fall considerably compared to the former five years of this study. Tea export showed an upward trend per month on average. The first four years from 2001 the tea export was declining, but from then the tea export was increasing up to 2016.
2. The ARDL regression analysis in the short-run noted the reduced coffee prices due to increased exchange rate volatility in the previous month whereas in the long-run, increased coffee prices were observed with increased exchange rate volatility. For tea, the increased exchange rate volatility led to the reduced export prices of tea in the market in the short-run.
3. There was an optimistic effect between exchange rate fluctuations with respect to export volumes of coffee in the previous months while in the long-run, the shock reduced volumes of coffee exported.

## 5.2 Recommendations

There is a need to review the monetary policy and address the issue of exchange rate volatility in agricultural export. 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.

Producers: Therefore firms need to increase efficiency, diversify their range of products and aggressively search for niche markets to boost competitiveness.

To avoid exchange rate risk in the short term, firms should require hedging of their currency exposures. Hedging will involve taking of a position, by obtaining a cash flow, an asset or a contract; including a forward looking contract that will rise in value and offset a fall in the value of an existing contract. In the long run, economic policies aimed at stabilizing the exchange rate are likely to increase the volumes of coffee and tea exports from Rwanda. In order to cushion exporters from high exchange rate volatility, the government needs to develop forward markets in the coffee and tea exports sub-sector.

### 5.3 Areas for future research

Further researches are 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. There is need to analyze not only the effect of exchange rate volatility on exports but also its effect on Rwandan imports. Further research could also evaluate whether the sources of exchange rate volatility determine its effects on exports. Furthermore, studies should go beyond just the responsiveness of agricultural export to exchange rate fluctuation but also examine the competitiveness of Rwandan agricultural exports on the international market.

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# APPENDIX

## **Appendix A:** Tea price model selection

Dependent Variable: TEAPRICEUSDLN
Method: ARDL
Date: 08/31/17 Time: 15:34
Sample (adjusted): 2005M04 2016M12
Included observations: 141 after adjustments
Maximum dependent lags: 24 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (24 lags, automatic): IP_WNOTADJLN XRATEFORE
HTTRUEFORE
Fixed regressors: X1 X2 X3 C @TREND
Number of models evalulated: 375000
Selected Model: ARDL(24, 24, 23, 23)
Note: final equation sample is larger than selection sample

| Variable | Coefficient | Std. Error | t-Statistic | Prob.* |
|---|---|---|---|---|
| TEAPRICEUSDLN(-1) | 0.157369 | 0.127881 | 1.230589 | 0.2258 |
| TEAPRICEUSDLN(-2) | 0.206042 | 0.129546 | 1.590500 | 0.1198 |
| TEAPRICEUSDLN(-3) | 0.029849 | 0.140193 | 0.212912 | 0.8325 |
| TEAPRICEUSDLN(-4) | -0.079812 | 0.147949 | -0.539453 | 0.5926 |
| TEAPRICEUSDLN(-5) | -0.012435 | 0.143410 | -0.086708 | 0.9313 |
| TEAPRICEUSDLN(-6) | 0.268716 | 0.141308 | 1.901638 | 0.0646 |
| TEAPRICEUSDLN(-7) | 0.202136 | 0.145143 | 1.392663 | 0.1716 |
| TEAPRICEUSDLN(-8) | -0.147883 | 0.104066 | -1.421054 | 0.1632 |
| TEAPRICEUSDLN(-9) | 0.174054 | 0.095970 | 1.813630 | 0.0774 |
| TEAPRICEUSDLN(-10) | -0.079270 | 0.092392 | -0.857968 | 0.3962 |
| TEAPRICEUSDLN(-11) | -0.011273 | 0.096019 | -0.117399 | 0.9071 |
| TEAPRICEUSDLN(-12) | 0.131616 | 0.090182 | 1.459440 | 0.1525 |
| TEAPRICEUSDLN(-13) | -0.045626 | 0.091220 | -0.500173 | 0.6198 |
| TEAPRICEUSDLN(-14) | -0.157377 | 0.091226 | -1.725125 | 0.0924 |
| TEAPRICEUSDLN(-15) | -0.027981 | 0.082477 | -0.339258 | 0.7362 |
| TEAPRICEUSDLN(-16) | 0.010961 | 0.081370 | 0.134705 | 0.8935 |
| TEAPRICEUSDLN(-17) | 0.068047 | 0.083821 | 0.811806 | 0.4218 |
| TEAPRICEUSDLN(-18) | -0.010474 | 0.088916 | -0.117797 | 0.9068 |
| TEAPRICEUSDLN(-19) | -0.097570 | 0.089441 | -1.090895 | 0.2820 |
| TEAPRICEUSDLN(-20) | -0.005051 | 0.086985 | -0.058063 | 0.9540 |
| TEAPRICEUSDLN(-21) | 0.022361 | 0.078935 | 0.283282 | 0.7785 |
| TEAPRICEUSDLN(-22) | 0.145704 | 0.079783 | 1.826249 | 0.0755 |
| TEAPRICEUSDLN(-23) | -0.067016 | 0.081347 | -0.823827 | 0.4150 |
| TEAPRICEUSDLN(-24) | -0.108406 | 0.070051 | -1.547534 | 0.1298 |
| IP_WNOTADJLN | -0.195178 | 0.559143 | -0.349066 | 0.7289 |
| IP_WNOTADJLN(-1) | 0.397119 | 0.557809 | 0.711927 | 0.4807 |
| IP_WNOTADJLN(-2) | 0.824629 | 0.541957 | 1.521576 | 0.1362 |
| IP_WNOTADJLN(-3) | -0.103798 | 0.564557 | -0.183857 | 0.8551 |
| IP_WNOTADJLN(-4) | -0.061674 | 0.637631 | -0.096723 | 0.9234 |
| IP_WNOTADJLN(-5) | -0.393575 | 0.591835 | -0.665007 | 0.5100 |
| IP_WNOTADJLN(-6) | 0.606623 | 0.565774 | 1.072199 | 0.2902 |
| IP_WNOTADJLN(-7) | -0.656428 | 0.626255 | -1.048181 | 0.3010 |
| IP_WNOTADJLN(-8) | 0.729806 | 0.664400 | 1.098443 | 0.2787 |
| IP_WNOTADJLN(-9) | -0.570506 | 0.621003 | -0.918685 | 0.3639 |
| IP_WNOTADJLN(-10) | -0.399048 | 0.664799 | -0.600254 | 0.5518 |
| IP_WNOTADJLN(-11) | 0.223506 | 0.617610 | 0.361889 | 0.7194 |
| IP_WNOTADJLN(-12) | 0.882924 | 0.780247 | 1.131595 | 0.2647 |
| IP_WNOTADJLN(-13) | 0.077730 | 0.673487 | 0.115414 | 0.9087 |
| IP_WNOTADJLN(-14) | -0.735816 | 0.561552 | -1.310324 | 0.1978 |
| IP_WNOTADJLN(-15) | 0.182880 | 0.562791 | 0.324952 | 0.7470 |
| IP_WNOTADJLN(-16) | 0.065579 | 0.624790 | 0.104962 | 0.9169 |

| | | | | |
|---|---|---|---|---|
| IP_WNOTADJLN(-17) | -0.493816 | 0.527848 | -0.935528 | 0.3553 |
| IP_WNOTADJLN(-18) | 0.047669 | 0.530535 | 0.089851 | 0.9289 |
| IP_WNOTADJLN(-19) | 0.396033 | 0.564313 | 0.701796 | 0.4870 |
| IP_WNOTADJLN(-20) | -0.281033 | 0.589490 | -0.476739 | 0.6362 |
| IP_WNOTADJLN(-21) | 0.602464 | 0.619353 | 0.972732 | 0.3367 |
| IP_WNOTADJLN(-22) | -0.442907 | 0.634025 | -0.698565 | 0.4890 |
| IP_WNOTADJLN(-23) | -0.034295 | 0.624929 | -0.054878 | 0.9565 |
| IP_WNOTADJLN(-24) | -1.875004 | 0.659665 | -2.842359 | 0.0071 |
| XRATEFORE | 2.479411 | 2.859562 | 0.867059 | 0.3912 |
| XRATEFORE(-1) | 1.744956 | 5.325881 | 0.327637 | 0.7449 |
| XRATEFORE(-2) | -7.108547 | 6.467740 | -1.099077 | 0.2785 |
| XRATEFORE(-3) | 14.04538 | 7.452533 | 1.884645 | 0.0669 |
| XRATEFORE(-4) | -15.32193 | 8.387841 | -1.826683 | 0.0754 |
| XRATEFORE(-5) | 18.62342 | 9.124493 | 2.041036 | 0.0481 |
| XRATEFORE(-6) | -24.79979 | 9.828655 | -2.523213 | 0.0158 |
| XRATEFORE(-7) | 23.15508 | 10.30725 | 2.246484 | 0.0304 |
| XRATEFORE(-8) | -19.59991 | 10.50214 | -1.866278 | 0.0695 |
| XRATEFORE(-9) | 25.99379 | 10.70780 | 2.427557 | 0.0199 |
| XRATEFORE(-10) | -31.71811 | 10.61613 | -2.987730 | 0.0048 |
| XRATEFORE(-11) | 24.65306 | 10.02191 | 2.459916 | 0.0184 |
| XRATEFORE(-12) | -20.29185 | 9.609901 | -2.111556 | 0.0412 |
| XRATEFORE(-13) | 28.98409 | 9.608442 | 3.016523 | 0.0045 |
| XRATEFORE(-14) | -28.37513 | 9.316823 | -3.045580 | 0.0041 |
| XRATEFORE(-15) | 21.86467 | 8.784088 | 2.489122 | 0.0172 |
| XRATEFORE(-16) | -21.41321 | 8.584764 | -2.494327 | 0.0170 |
| XRATEFORE(-17) | 21.03478 | 8.298268 | 2.534840 | 0.0154 |
| XRATEFORE(-18) | -21.38311 | 7.680628 | -2.784032 | 0.0082 |
| XRATEFORE(-19) | 17.13255 | 7.296855 | 2.347936 | 0.0240 |
| XRATEFORE(-20) | -14.01738 | 6.744917 | -2.078214 | 0.0443 |
| XRATEFORE(-21) | 13.77369 | 5.966124 | 2.308650 | 0.0264 |
| XRATEFORE(-22) | -14.10411 | 4.935183 | -2.857869 | 0.0068 |
| XRATEFORE(-23) | 9.324434 | 2.706512 | 3.445185 | 0.0014 |
| HTTRUEFORE | -2947.392 | 2138.752 | -1.378090 | 0.1760 |
| HTTRUEFORE(-1) | -1708.207 | 2052.111 | -0.832415 | 0.4102 |
| HTTRUEFORE(-2) | -1302.022 | 2010.391 | -0.647646 | 0.5210 |
| HTTRUEFORE(-3) | 573.5087 | 1972.152 | 0.290804 | 0.7727 |
| HTTRUEFORE(-4) | -171.5304 | 2111.390 | -0.081240 | 0.9357 |
| HTTRUEFORE(-5) | 1136.649 | 1966.521 | 0.578000 | 0.5666 |
| HTTRUEFORE(-6) | -2030.011 | 1824.648 | -1.112549 | 0.2727 |
| HTTRUEFORE(-7) | 711.8047 | 1794.776 | 0.396598 | 0.6938 |
| HTTRUEFORE(-8) | 262.3772 | 1864.816 | 0.140699 | 0.8888 |
| HTTRUEFORE(-9) | 3634.046 | 1763.320 | 2.060911 | 0.0460 |
| HTTRUEFORE(-10) | 285.1997 | 1757.608 | 0.162266 | 0.8719 |
| HTTRUEFORE(-11) | -2798.600 | 1713.228 | -1.633525 | 0.1104 |
| HTTRUEFORE(-12) | -2221.578 | 1678.037 | -1.323915 | 0.1932 |
| HTTRUEFORE(-13) | -1286.184 | 1789.117 | -0.718893 | 0.4765 |
| HTTRUEFORE(-14) | -602.6330 | 1704.524 | -0.353549 | 0.7256 |
| HTTRUEFORE(-15) | -2945.829 | 1718.544 | -1.714142 | 0.0944 |
| HTTRUEFORE(-16) | 2564.982 | 1709.150 | 1.500735 | 0.1415 |
| HTTRUEFORE(-17) | 1318.252 | 1716.876 | 0.767820 | 0.4472 |
| HTTRUEFORE(-18) | -209.8839 | 1776.327 | -0.118156 | 0.9066 |
| HTTRUEFORE(-19) | 1895.229 | 1802.849 | 1.051241 | 0.2996 |
| HTTRUEFORE(-20) | -951.8832 | 1821.125 | -0.522690 | 0.6041 |
| HTTRUEFORE(-21) | 1651.801 | 1714.945 | 0.963180 | 0.3414 |
| HTTRUEFORE(-22) | -3378.088 | 1768.253 | -1.910409 | 0.0635 |
| HTTRUEFORE(-23) | 2380.178 | 1479.202 | 1.609096 | 0.1157 |

| | | | | |
|---|---|---|---|---|
| X1 | 0.077879 | 0.057722 | 1.349203 | 0.1851 |
| X2 | 0.029795 | 0.026836 | 1.110240 | 0.2737 |
| X3 | 0.017733 | 0.059819 | 0.296449 | 0.7685 |
| C | 11.58000 | 21.32512 | 0.543022 | 0.5902 |
| @TREND | 0.004042 | 0.002053 | 1.968906 | 0.0561 |

| | | | |
|---|---|---|---|
| R-squared | 0.989834 | Mean dependent var | 0.680834 |
| Adjusted R-squared | 0.963508 | S.D. dependent var | 0.287212 |
| S.E. of regression | 0.054866 | Akaike info criterion | -2.806246 |
| Sum squared resid | 0.117400 | Schwarz criterion | -0.673101 |
| Log likelihood | 299.8404 | Hannan-Quinn criter. | -1.939410 |
| F-statistic | 37.59857 | Durbin-Watson stat | 1.954150 |
| Prob(F-statistic) | 0.000000 | | |

*Note: p-values and any subsequent tests do not account for model selection.

**Appendix B:** Coffee export model selection

Dependent Variable: COFNETWEIGHTLN
Method: ARDL
Date: 08/31/17 Time: 10:30
Sample (adjusted): 2005M03 2016M12
Included observations: 142 after adjustments
Maximum dependent lags: 22 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (22 lags, automatic): IP_WNOTADJLN XRATEFORE HTTRUEFORE
Fixed regressors: X1 X2 X3 C @TREND
Number of models evalulated: 267674
Selected Model: ARDL(22, 22, 22, 15)

| Variable | Coefficient | Std. Error | t-Statistic | Prob.* |
|---|---|---|---|---|
| COFNETWEIGHTLN(-1) | -0.253833 | 0.124639 | -2.036544 | 0.0467 |
| COFNETWEIGHTLN(-2) | -0.188933 | 0.119419 | -1.582102 | 0.1196 |
| COFNETWEIGHTLN(-3) | -0.413923 | 0.116586 | -3.550378 | 0.0008 |
| COFNETWEIGHTLN(-4) | -0.184657 | 0.127646 | -1.446639 | 0.1539 |
| COFNETWEIGHTLN(-5) | -0.179702 | 0.124625 | -1.441945 | 0.1552 |
| COFNETWEIGHTLN(-6) | -0.293779 | 0.114076 | -2.575287 | 0.0128 |
| COFNETWEIGHTLN(-7) | -0.151327 | 0.122209 | -1.238271 | 0.2211 |
| COFNETWEIGHTLN(-8) | -0.309168 | 0.123263 | -2.508193 | 0.0152 |
| COFNETWEIGHTLN(-9) | -0.456242 | 0.116676 | -3.910352 | 0.0003 |
| COFNETWEIGHTLN(-10) | -0.290093 | 0.122876 | -2.360859 | 0.0219 |
| COFNETWEIGHTLN(-11) | -0.286557 | 0.119185 | -2.404310 | 0.0197 |
| COFNETWEIGHTLN(-12) | -0.340260 | 0.102588 | -3.316773 | 0.0016 |
| COFNETWEIGHTLN(-13) | -0.122917 | 0.107500 | -1.143418 | 0.2580 |
| COFNETWEIGHTLN(-14) | -0.158012 | 0.109261 | -1.446195 | 0.1540 |
| COFNETWEIGHTLN(-15) | -0.122908 | 0.105047 | -1.170026 | 0.2472 |
| COFNETWEIGHTLN(-16) | -0.022530 | 0.106182 | -0.212180 | 0.8328 |
| COFNETWEIGHTLN(-17) | -0.198405 | 0.109261 | -1.815876 | 0.0750 |
| COFNETWEIGHTLN(-18) | -0.303580 | 0.116873 | -2.597526 | 0.0121 |
| COFNETWEIGHTLN(-19) | -0.255123 | 0.128960 | -1.978314 | 0.0531 |
| COFNETWEIGHTLN(-20) | -0.277576 | 0.116782 | -2.376885 | 0.0211 |
| COFNETWEIGHTLN(-21) | -0.304874 | 0.116526 | -2.616362 | 0.0116 |
| COFNETWEIGHTLN(-22) | -0.281602 | 0.119340 | -2.359656 | 0.0220 |
| IP_WNOTADJLN | 38.47579 | 19.43925 | 1.979284 | 0.0530 |
| IP_WNOTADJLN(-1) | 46.86208 | 22.49873 | 2.082877 | 0.0421 |
| IP_WNOTADJLN(-2) | 1.659896 | 26.33405 | 0.063032 | 0.9500 |
| IP_WNOTADJLN(-3) | -29.00043 | 24.55936 | -1.180830 | 0.2429 |
| IP_WNOTADJLN(-4) | 4.936470 | 27.43078 | 0.179961 | 0.8579 |
| IP_WNOTADJLN(-5) | 5.716996 | 26.56730 | 0.215189 | 0.8304 |
| IP_WNOTADJLN(-6) | 17.61385 | 27.06382 | 0.650826 | 0.5180 |
| IP_WNOTADJLN(-7) | -2.912466 | 27.50897 | -0.105873 | 0.9161 |
| IP_WNOTADJLN(-8) | -12.38550 | 26.21071 | -0.472536 | 0.6385 |
| IP_WNOTADJLN(-9) | 13.31641 | 24.52092 | 0.543063 | 0.5894 |
| IP_WNOTADJLN(-10) | -19.45477 | 25.91073 | -0.750839 | 0.4561 |
| IP_WNOTADJLN(-11) | 30.89318 | 14.13681 | 2.185300 | 0.0333 |
| IP_WNOTADJLN(-12) | 9.529552 | 23.05400 | 0.413358 | 0.6810 |
| IP_WNOTADJLN(-13) | -35.23786 | 25.87609 | -1.361792 | 0.1790 |
| IP_WNOTADJLN(-14) | 20.11889 | 26.98828 | 0.745468 | 0.4593 |
| IP_WNOTADJLN(-15) | 37.70888 | 28.54066 | 1.321234 | 0.1921 |
| IP_WNOTADJLN(-16) | -23.63742 | 31.23149 | -0.756846 | 0.4525 |
| IP_WNOTADJLN(-17) | -9.327116 | 26.78859 | -0.348175 | 0.7291 |
| IP_WNOTADJLN(-18) | -48.13902 | 28.53735 | -1.686878 | 0.0975 |
| IP_WNOTADJLN(-19) | 34.36126 | 28.02676 | 1.226016 | 0.2256 |

| | | | | |
|---|---|---|---|---|
| IP_WNOTADJLN(-20) | 45.82415 | 26.04237 | 1.759600 | 0.0842 |
| IP_WNOTADJLN(-21) | 8.217254 | 26.38215 | 0.311470 | 0.7567 |
| IP_WNOTADJLN(-22) | 37.16114 | 23.87242 | 1.556656 | 0.1255 |
| XRATEFORE | 42.25336 | 91.22843 | 0.463160 | 0.6451 |
| XRATEFORE(-1) | 106.8849 | 173.2225 | 0.617038 | 0.5399 |
| XRATEFORE(-2) | -230.7922 | 200.4644 | -1.151288 | 0.2548 |
| XRATEFORE(-3) | 168.4813 | 225.3876 | 0.747518 | 0.4581 |
| XRATEFORE(-4) | -240.3191 | 259.0996 | -0.927516 | 0.3579 |
| XRATEFORE(-5) | 501.8622 | 282.9677 | 1.773567 | 0.0819 |
| XRATEFORE(-6) | -543.6411 | 298.0525 | -1.823978 | 0.0738 |
| XRATEFORE(-7) | 571.3010 | 311.3473 | 1.834931 | 0.0721 |
| XRATEFORE(-8) | -657.5416 | 327.1861 | -2.009687 | 0.0496 |
| XRATEFORE(-9) | 690.0212 | 334.9167 | 2.060277 | 0.0443 |
| XRATEFORE(-10) | -752.6702 | 334.4812 | -2.250262 | 0.0286 |
| XRATEFORE(-11) | 759.6716 | 335.3909 | 2.265034 | 0.0276 |
| XRATEFORE(-12) | -531.7340 | 338.1827 | -1.572328 | 0.1218 |
| XRATEFORE(-13) | 413.0072 | 328.7499 | 1.256296 | 0.2145 |
| XRATEFORE(-14) | -452.7467 | 313.3158 | -1.445017 | 0.1543 |
| XRATEFORE(-15) | 307.7174 | 301.5799 | 1.020351 | 0.3122 |
| XRATEFORE(-16) | -495.0219 | 289.6849 | -1.708829 | 0.0933 |
| XRATEFORE(-17) | 526.9985 | 269.8920 | 1.952627 | 0.0562 |
| XRATEFORE(-18) | -429.3057 | 251.3807 | -1.707791 | 0.0935 |
| XRATEFORE(-19) | 458.4749 | 224.0805 | 2.046028 | 0.0457 |
| XRATEFORE(-20) | -273.8783 | 189.3202 | -1.446641 | 0.1539 |
| XRATEFORE(-21) | 271.7739 | 159.5195 | 1.703703 | 0.0943 |
| XRATEFORE(-22) | -163.4330 | 83.08088 | -1.967155 | 0.0544 |
| HTTRUEFORE | -38182.75 | 67829.90 | -0.562919 | 0.5759 |
| HTTRUEFORE(-1) | 81148.94 | 70408.32 | 1.152548 | 0.2543 |
| HTTRUEFORE(-2) | -40461.81 | 65428.56 | -0.618412 | 0.5390 |
| HTTRUEFORE(-3) | -44743.18 | 65433.41 | -0.683797 | 0.4971 |
| HTTRUEFORE(-4) | 7735.637 | 65818.28 | 0.117530 | 0.9069 |
| HTTRUEFORE(-5) | 123082.4 | 65095.17 | 1.890806 | 0.0641 |
| HTTRUEFORE(-6) | -108143.2 | 66390.13 | -1.628905 | 0.1093 |
| HTTRUEFORE(-7) | -33160.26 | 65661.33 | -0.505020 | 0.6156 |
| HTTRUEFORE(-8) | -89569.68 | 66052.15 | -1.356045 | 0.1808 |
| HTTRUEFORE(-9) | -35851.01 | 66290.96 | -0.540813 | 0.5909 |
| HTTRUEFORE(-10) | 68748.28 | 69176.38 | 0.993811 | 0.3248 |
| HTTRUEFORE(-11) | 27552.57 | 66858.95 | 0.412100 | 0.6819 |
| HTTRUEFORE(-12) | 11985.66 | 66630.63 | 0.179882 | 0.8579 |
| HTTRUEFORE(-13) | -50600.04 | 64221.44 | -0.787900 | 0.4343 |
| HTTRUEFORE(-14) | -82438.81 | 65686.04 | -1.255043 | 0.2150 |
| HTTRUEFORE(-15) | -81669.53 | 56993.49 | -1.432962 | 0.1577 |
| X1 | -1.172668 | 2.605423 | -0.450087 | 0.6545 |
| X2 | 0.589308 | 2.547613 | 0.231318 | 0.8180 |
| X3 | 4.794600 | 2.826177 | 1.696497 | 0.0957 |
| C | -4921.040 | 776.0327 | -6.341279 | 0.0000 |
| @TREND | -0.355086 | 0.056879 | -6.242801 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.840620 | Mean dependent var | 12.99373 |
| Adjusted R-squared | 0.575989 | S.D. dependent var | 3.491489 |
| S.E. of regression | 2.273522 | Akaike info criterion | 4.748524 |
| Sum squared resid | 273.9519 | Schwarz criterion | 6.601119 |
| Log likelihood | -248.1452 | Hannan-Quinn criter. | 5.501343 |
| F-statistic | 3.176575 | Durbin-Watson stat | 2.063857 |
| Prob(F-statistic) | 0.000007 | | |