SUPPLY RESPONSE OF KENYAN COFFEE IN THE WORLD MARKET

STEPHEN GITHAE NJARAMBA

A RESEARCH PROJECT SUBMITTED TO THE SCHOOL OF ECONOMICS IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF ECONOMICS DEGREE OF KENYATTA UNIVERSITY

NOVEMBER, 2011

DECLARATION

This research project is my original work and has not been presented for an academic award in any University

Signature _____ Date 02/12/2011

Stephen Githae Njaramba

Reg. No: K102/13086/2009

This research project has been submitted to the school of economics, Kenyatta University, with our approval as supervisors.

Signature _____ Date 2-12-2011

Prof. Martin N. Etyang
Department of Economic Theory
Kenyatta University
Nairobi, Kenya

Signature _____ Date 02-12-2011

Dr. George Kosimbei
Department of Economic Theory
Kenyatta University
Nairobi, Kenya

DEDICATION

To

My parents and my family

ACKNOWLEDGEMENTS

To God I give thanks for the opportunity, the strength and energy to come this far. Secondly I am indebted to my supervisors Prof. Martin Etyang and Dr. George Kosimbei for the immense support, guidance and contribution in making this research project what it is. I would want to acknowledge Ms Iddah Mugambi and my classmates who went out of their way to read my draft research project, made corrections and gave a lot of support. I also thank the lecturers in School of Economics, Kenyatta University for their invaluable contribution they gave in realisation of this project. The prayers and support from my family and friends are appreciated. Finally I am thankful to the government of Kenya through the Ministry of State for Planning, National Development and Vision 2030 for the scholarship and opportunity to study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

ADF	Augmented Dicky Fuller
AERC	African Economic Research Consortium
ARDL	Autoregressive Distributive Lag
CBK	Coffee Board of Kenya
CPI	Consumer Price Index
ECM	Error Correction Model
EPZA	Export Processing Zone Authority
F.o.b	Free on board
FAO	Food and Agricultural Organisation
ICA	International Coffee Agreement
ICO	International price Organisation
KIPPRA	Kenya Institute of Public Policy and Research Analysis
KNBS	Kenya National Bureau of Statistics
KPCU	Kenya Planters Cooperative Union
KTDA	Kenya Tea Development Authority.
MT	Metric tons

ABSTRACT

The drastic drop in Kenya coffee supply in the last twenty years has severely affected the country's export revenues as well as the livelihoods of two million small scale producers and over six million people who directly or indirectly depend on coffee. In spite of the central role which coffee has played in the county's development, Coffee production has shown a steady decline over the last two decades. Coffee production declined from an all time high of about 130,000 metric tons in 1987/88 to a low of about 42,000 metric tons in the 2010 coffee calendar year

In this study the objective was to estimate the response of Kenyan coffee which is supplied at the world market. Coffee is an important crop to Kenya since it is a source of foreign exchange. It is also the main agricultural enterprise in some of the districts in the country and the major source of income to these districts. Therefore the research project sought to come up with the supply function of Kenyan coffee to the international market. Coffee supply in Kenya has continued to decline despite policy reforms in the coffee sector. The principal of cointegration and Error Correction Model were used to establish the effect of various variables to the supply of coffee to the international market.

Despite the popular belief that falling international prices paid for coffee is the course of decline of supply from Kenya, this study found out that the international prices did not have significant effect on the supply of coffee from Kenya to the international market. Rather the supply is affected by cost of inputs both in the short and long run, the cost of moving coffee from the farm to the market, weather and the policies employed by the government. All the other variables were found to be insignificant at 5 percent level.

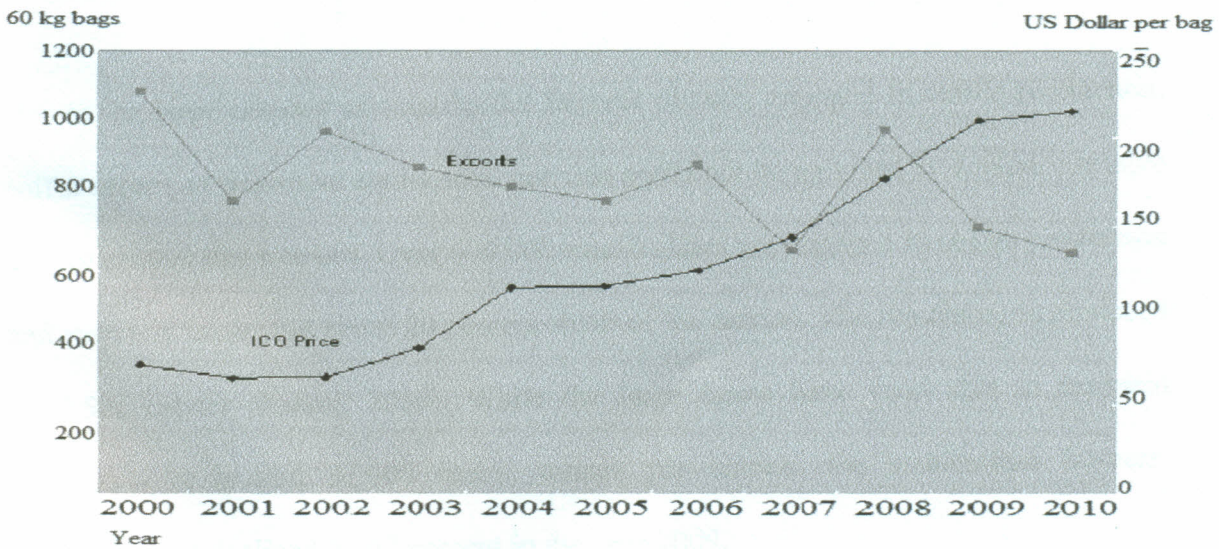
CHAPTER ONE

INTRODUCTION

1.1 Background

There is growing concern that Kenya's supply of coffee to the world market continues to decline, as world coffee trade continues to increase from year-to-year (Ojambo, 2010). Historically, coffee has been an important commodity in Kenya because of its contribution to foreign exchange earnings, farm incomes and employment opportunities. Prior to 1988, coffee was Kenya's leading foreign exchange earner and currently ranks fourth after tourism, tea and horticulture, accounting for 10 percent of the total export earnings in the year 2000 and 2 percent in 2009 (Export Processing Zones Authority, 2010).

Figure 1.1 below shows that Kenya coffee exports as a percent of world coffee trade have continued to lose market share despite its high quality in the world market.



Source: FAO Nairobi (2011)

Figure 1.1 Kenya Coffee Exports Against ICO Prices

The price increase for coffee does not appear sufficient to stimulate increased exportable surpluses in Kenya. While the world coffee prices continue their upward trend as shown in figure 1.1, the Kenya coffee export trend drops. There are therefore likely to be many other factors that have led to this poor response of coffee supply to the increasing price incentive. These factors may include the conversion of plantations to housing developments, high and increasing transportation charges and generally poor and deteriorating infrastructure.

The world supply of coffee has been expanding by 1.5 per cent per annum as the demand of the product continues to grow (ICO, 2009). The increase in coffee supply in the recent past has been attributed to supply increases from Brazil and Vietnam. Vietnam alone has increased its supply to the world market by 1,400 percent between 1990 and 2009 while Brazil has increased its production by 31 percent (ICO, 2009). This therefore shows that other countries are taking positions previously occupied by Kenya in the supply of coffee to the world market.

Due to the large number of smallholder farmers directly engaged in coffee production, coffee serves an important equity role, one that could not be matched by capital-intensive service sectors like tourism. Over 600,000 smallholders are engaged in coffee production and currently command about 20 percent share of the market. The remaining is produced on 2,500 estates (Kinoti, 2010). While the large farms have been able to maintain production at around 32,000 metric tonnes per annum, the smallholder farmers' production has declined by 47 percent in the year 2009.

Over 98 percent of the coffee produced in Kenya is supplied to the international market and only 1 percent to 2 percent is consumed locally (Gitau, 2009). At the household level, income from coffee accounts for a major proportion of total farm income in the coffee growing areas. These incomes have important multiplier effects in the national economy and more so in rural areas. The decline in coffee incomes has a direct bearing on poverty in most coffee growing areas. Furthermore, coffee incomes are normally used to finance major household expenditures such as school fees, investments and health care.

Transaction and coffee handling costs have escalated in the recent past mainly due to major increases in the cost of middlemen and transportation. Currency devaluation, inflation and inefficient input markets have been some of the factors behind the increase in costs. Poor road infrastructure also has significantly contributed to the high costs of inputs due to high transport costs. Coffee handling costs tripled from Kshs 26,000 in 1990/91 to Kshs 66,000 per tonne in 2000/01 (Karanja and Nyoro, 2002). The increases in costs, when juxtaposed on the declining and low farm supply, decline in coffee prices paid out to the suppliers, and enhanced price and performance risks have made returns to coffee supply to dwindle in the recent past.

Due to the loss experienced in the coffee sector, many reforms aimed at restructuring the industry have been carried out and can be traced back to the year 1992 and the end of the ICA quota regime (Gitau, 2009). Some of the initiatives were aimed at giving smallholder farmers loans for purchasing inputs (example, in 2001 a total of Kshs I billion was given to Co-operative bank of Kenya for fast track lending to coffee farmers

to buy inputs). Other incentives that were introduced included advance payment for the coffee supplied by the farmers, training services to the farmers, rehabilitation of roads in the coffee growing areas, electrification of coffee factories and the building of laboratories at the Coffee Research Foundation (CRF). The monopoly of KPCU experienced before 1992 was lifted. Government regulations in the coffee industry were also reduced and power of marketing granted to the farmers.

1.2 Overview of coffee production.

Coffee is one of the world's largest traded commodities produced in more than 60 countries, providing a livelihood for some 25,000,000 coffee farming families around the world (ICO, 2006). Many of these countries are heavily dependent on coffee, which can account for over 75 percent of their total exports earnings. Among world consumers, coffee is a universally popular drink, with over US$70 billion in retail sales a year (Erdmann and Engel, 2007). According to the International Coffee Organisation (ICO), exporting members account for over 97 percent of world coffee production while importing Members are responsible for 56 percent of world coffee consumption.

Coffee is produced in various regions of the World including East Africa, Central America, South America, West Africa and the Middle East. Brazil is the world's largest producer of coffee, producing both Arabica and Robusta types of coffee (Nyangito, 2002).

It has been argued that the essential characteristics of the global coffee industry have changed significantly following the collapse of the International Coffee Agreement

(ICA) in 1989. This post-ICA regime has been characterised as a buyer-driven chain, or more specifically, a roaster-driven chain, in which the strategic decisions by coffee roasters set the barriers to entry and political negotiation over quotas have been replaced by market relations (Ponte, 2002). This has led to a growing gap between producer and retail prices because the entrance of new coffee roasters on market is made difficult by the enormous size of major coffee roasters which not only enjoy economies of scale but have also made huge investments in branding and advertising to secure their market share. In addition, coffee products are sold in supermarkets, which have made it easy for supermarket chains to increase their profit margins by not passing producer price decreases on to consumer prices (Oxfam, 2001). As a result, while producers retained an average of about 20 percent of the total income generated by roast and ground sales during the 1980s compared to 55 percent in consuming countries, the average proportion gained by producers dropped to around 13 percent during the 1990s whilst the proportion retained in consuming countries rose to 78 percent (Daviron and Ponte, 2005).

1.3 Overview of Agricultural sector in Kenya

Agriculture is a dominant sector in the Kenyan economy accounting for 24 percent of the country's Gross Domestic Product as at 2003 (Export Processing Zones Authority 2005). The sector is the largest contributor of foreign exchange through export earnings from tea, coffee and horticulture. Agriculture also provides employment and livelihood to a large proportion of the population. Currently an estimated 75 percent of the population depends on the sector either directly or indirectly (Gitau, 2009).

Kenya's principal cash crops are tea, coffee (mainly Arabica grown by smallholders), sugar, cotton, pyrethrum, sisal, tobacco, pineapples and wattle. Tea, coffee and horticultural produce provided 55 percent of merchandise exports revenue in 2003. The combined revenue from coffee and tea of KShs 39,291 million contributed 29 percent to the total revenue generated from exports in 2003. During the same year, beverage crops (coffee, tea and sugar) realized total revenue of KShs 58.36 billion compared to KShs 60.21 billion the previous year (Export Processing Zones Authority 2005).

1.4 Policies and Institutional Reforms in the coffee sector.

The emerging of policies and institutional reforms to address the decline of coffee output impacted both positively and negatively on smallholder farmers' welfare. On the positive side, the reforms have reduced the government involvement in coffee matters while encouraging farmers and private sector participation. Gains arising from lower processing costs and statutory deductions were also anticipated as a result of enhanced competition. It was also expected that delays in payments would be minimised. Nevertheless, the politicisation of co-operatives has led to splits that continue to erode their economies of scale (Karanja, 2004). There has also been an increase in governance problems that have led to mismanagement of coffee co-operatives. Corruption, lack of financial accountability and transparency by the co-operative officials are some of the mismanagement issues that cut across most institutions in the coffee industry including co-operatives. The farmers more than ever before were exposed to price risks arising from fluctuations of coffee prices, exchange rates and performance risks in marketing

institutions. The reform period has also been accompanied by under capacity utilisation in coffee processing and milling, factors that do not augur well for the farmers' returns.

However, despite many reforms, this did not solve the problems and in recent years, contribution of coffee to the economy in terms of foreign exchange earnings and employment has been steadily declining (Export Processing Zone, 2010). A number of studies have tried to trace the course of decline in production to lack of credit facilities by the farmers and the large number of middle men. Focus has also been on the corruption and mismanagement as possible issues why many reforms carried out have not been of much help in resuscitating the coffee industry.

1.5 The Statement of the Problem

Several studies have been done on coffee supply for example Stewart (1992), Asmeron (1999), Oxfam (2001), Karanja and Nyoro (2002), Nyangito (2002), Daviron and Pante (2005), Luttinger and Dicum (2006), Kiptui (2007) and Gitau, (2009). However, given the importance of the coffee crop in Kenya's economy, there are only few studies that have been done to determine response of coffee to both price and non price factors in Kenya (Maitha, 1966 and Gatete, 1993). None of these studies however, estimated the supply function for coffee in Kenya, incorporating policies and institutional reforms meant to address the decline that has been experienced in the sector (see Figure 1.1). There has been an increase in the world price paid for coffee supply and the demand for the product has been expanding, therefore giving an investment guarantee in the industry. Probably, the reasons for the dismal performance in the Kenya supply is the lack of a realistic supply function for Kenyan coffee to the world market that would explain

interactive effects of various variables to aid in policy formulation. With this realisation therefore, this study undertook to estimate the supply response of Kenyan coffee to the world market.

1.6 Research Questions

This study sought to find answers to the following questions:

i. What were the determinants of coffee supply to the world market?

ii. What was the short run and long run estimates of the coffee supply elasticity in Kenya?

1.7 Objectives of the Study

The general objective of this study was to estimate the response of coffee supply in Kenya.

The specific objectives were to:

i. Establish the determinants of supply of Kenyan coffee to the world market.

ii. Determine the short run and long run elasticity of coffee supply

iii. Recommend policy measures on the basis of findings.

1.8 Significance of the Study

Understanding supply function of coffee in Kenya was critical as it would make the policy makers regulate the supply based on the variables that affect supply. The function could be used to forecast the level of supply given the changes in the exogenous variables and protect coffee producers from overall adverse economic conditions such as exploitation by the middlemen. The study contributes to the understanding of how the supply of coffee changes with the various variables.

By identifying various factors affecting supply of coffee in Kenya, the policy makers can influence the variables to influence the supply. Therefore, a study on the effect of local and international factors of coffee supply adds to knowledge of factors affecting the local coffee supply.

1.9 Scope of the Study

The study utilized coffee supply data available from the Coffee Board of Kenya and other relevant sources. The data for coffee supply was for the whole country and was from year 1974 to 2010 so as to capture equal periods of before and after reforms that started in the year 1992.

1.10 Organization of the study

The research project is organised in five chapters. This chapter introduced the study by highlighting its principal objectives and stating the research problem. Chapter two is devoted to reviewing the relevant theoretical and empirical literature and ends by presenting the overview of literature. Chapter three highlights the research design and methodology used in the study, chapter four presents the findings of the study while chapter five gives the summary, conclusions and policy recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter is divided into three sections. The first section is the theoretical literature which reviews the existing theories of supply. The second section reviews empirical literature on studies carried out on supply of agricultural products and coffee supply in Kenya. The final section gives an overview of existing literature showing the gap that is to be filled by the current study.

2.2 Theoretical Literature

Profit Function Approach to Supply

The hypothesis in profit function approach to the supply is that, farmers attempt to maximize profit which is defined as the return to the variable factors. The restricted profit function (Lau, 1976) is defined as follow.

$$\Pi (P, Z) = \text{Max } \{(P.Y/_{Y \epsilon T (Z),\, z \epsilon Z}\} \quad \text{.....2.1}$$

Where Y is a vector of outputs ($y_i>0$) and inputs ($y_i<0$); P is a vector of output and input prices; Z is a set of fixed or environmental factors and T summarises the state of technology constrained by Z. The elements in Z include, rainfall, fixed land endowment, government policy, etc. These factors condition the level of profit which is attainable by farmers.

The farmers' problem is to determine the level of output to produce and input to use. The profit function is linearly-homogenous in prices. For the profit function to represent competitive, profit maximising behaviour, further restrictions include strict convexity and

second order differentiability. If these conditions are met, then the application of Hotelling's Lemma yields the following supply function:

$$y_i = \frac{\delta\pi}{\delta pi} \quad \text{.....2.2}$$

for $y_i > 0$

Farmers producing coffee are purely motivated by profit and therefore the profit maximising theory gives a good base for analysing farmers supply behaviour. This study therefore adopted the profit maximisation method to estimate the supply response of coffee in Kenya.

Structural Model and Reduced Form Model Approach to Supply

Typically a model can be expressed as a system of equations, each equation involving some relationships among the exogenous variables and the parameters. The system of equations form structural model.

For a simple demand and supply system;

$D = a_0 - a_1P + a_2Z_1 + \varepsilon_1$ 2.3

$S = b_0 + b_1P + b_2Z_2 + \varepsilon_2$ 2.4

$D = S$ 2.5

D and S represent the demand and supply respectively for some good (coffee), P is its price, a_1 and b_1 are parameters and Z_1 and Z_2 are other exogenous variables that affect demand and supply respectively.

Solving the structural system in a way that expresses the endogenous variable P as a function of exogenous variables yields the following equation:

$$P = \frac{a_0 - b_0}{a_1 + b_1} + \frac{a_2}{a_1 + b_1} Z_1 - \frac{b_2}{a_1 + b_1} Z_2 + \frac{\varepsilon_2 - \varepsilon_1}{a_1 + b_1} \quad \text{.....2.6}$$

This gives the reduced form of the system. The reduced equation then is estimated as the equation below:

$$P = B_0 + B_1 Z_1 + B_2 Z_2 + \varepsilon \quad \text{.....2.7}$$

It will not be possible to recover unique estimates of the structural parameters (a_i and b_i) from the reduced form parameters (B_i). The reduced-form parameters can be used to predict how the equilibrium price will change as the exogenous variables change.

Adaptive Expectations and Partial Adjustment Models

The approach to many empirical analysis in agricultural products supply has been Adaptive Expectations and Partial Adjustment Models based on lagged adjustments and expectations. The Nerlove Partial adjustment model has been extensively used in modelling the agricultural supply response. Many analysts have applied it in connection with adaptive expectation (Askari and Cummings, 1977).

According to Nerlove, 1979, a simple partial adjustment model results from minimisation of a single period loss function that takes the form:

$$L = \Theta_1 (y_t + y^*_t)^2 + \Theta_2 (y_t - y_{t-1})^2 \quad \text{.....2.8}$$

Where y* is a fixed long-run equilibrium or desired value of a given variable y. If L is minimised with respect to y_t, the following partial adjustment model results:

$$y_t - y_{t-1} = \Delta y_t = (\theta_1 / \theta_2)\,(y^*_t - y_t) \quad \text{.....2.9}$$

Where y_t is usually parameterised in terms of expected product and input prices.

Static expectation of the above model results in a fixed target for y towards which actual value adjusts.

The idea of a fixed target has been widely criticised in economic literature (example Nerlove, 1979), as unrealistic in the context of optimising behaviour under dynamic conditions.

2.3 Empirical Literature

Supply functions have been estimated for several export farm products from Africa. The approach to many empirical analyses in agriculture supply has been partial adjustment model based on lagged adjustments and expectations. Other studies have applied cointegration analysis to address the issue of spurious regressions in the analysis of non-stationary data.

Awudu and Rieder (2005) studied the impact of agricultural price policy on cocoa supply in Ghana. The study used error correction model to avoid the partial adjustment model's unrealistic assumption of a fixed target supply based on stationary expectation.

The equation used is:

$$A_t^c = \alpha + A_{t-1}^c + B_1P_t^c + B_2P_t^m + B_3M_t^s + B_4W_t + B_5D_t + \varepsilon_t \quad \text{.....2.10}$$

Where A_t^c refers to cocoa output, A_{t-1}^c is lagged cocoa output, P_t^c is the producers price for cocoa, P_t^m is the maize producers price which is used to represent price for substitute crops. Since maize competes with cocoa for land and other factors of production, its price is used to represent the price of substitute. M_t^s is an index of manufactured goods supply (mainly consumer goods). The variable is used to show that the farmer is not only motivated by the money he receives for his cash crops, but also by the goods and services he can buy with it. W_t represents the effect of weather, D_t is a dummy for major shocks

and ε_t is the error term. The real exchange rate variable is used to capture the impacts of macroeconomic disorders as part of major shocks.

The results revealed that cocoa supply is significantly influenced by the real producer price of cocoa, real price of maize, supply of manufactured goods and the real exchange rate. The supply of cocoa was found to be inelastic both in the short and long run.

Asmerom (1999) studied the response of coffee supply to exchange rates and prices. The objective was to see if devaluation affects agricultural prices and supply of coffee, a perennial crop that was the major source of foreign exchange in Ethiopia. After developing a model of perennial crop supply, panel data were gathered from small-scale farmers. The overall objective of the study was to determine the response of coffee farmers to changes in the domestic price of coffee. The model used by the study was adaptive expectation formation. Expectation formation involves the consideration of several variables: farmers face uncertainties about price and exchange rates, yields, wages, inflation and government policies. In other words, the decision to plant a coffee tree will have meaning only if one considers the future. Therefore the study on perennial crop supply assumed some relationship among prices in the near past, those in the present and those expected to prevail in the future. Because of this, the study assumed that a change in the expected price is proportional to the difference between the last actual price and the last expected price.

Both descriptive statistics as well as the econometric estimates (where fixed effect model was applied) showed that there was positive response for both the short run and the long run. In the former farmers were able to increase yields through increased use of labour and fertilizer on existing stock of trees. There was also an increase in the uprooting of old

trees and replacing them by new ones, as well as the use of extra acreage at the expense of other perennials and annuals crops.

Leaver (2003) studied the supply response of tobacco in Zimbabwe. The study objective was to present an estimate of the price elasticity of supply for tobacco output in Zimbabwe using an adapted Nerlovian model. The model for the annual crop consisted of the following three equations;

1. $A^*_t = a_0 + a_1P^*_t + a_2Z_t + u_t$ 2.11

2. $P^*_t = P^*_{t-1} + ß(P_{t-1} - P^*_{t-1})$.....2.12

3. $A_t = A_{t-1} + \alpha (A^*_t - A_{t-1})$.....2.13

Where A_t = actual area under cultivation at time t, A^*_t = desired area under cultivation at time t, P_t = actual price at time t, P^*_t = expected price at time t, Z_t = other observed, exogenous factors affecting supply at time t, ß and α are the expectation and adjustment coefficients respectively while u_t is the stochastic term.

By eliminating the unobservable variables associated with expected price and desired output from equations 2.11, 2.12 and 2.13, we get the reduced form Nerlovian equation. The reduced form is given as:

$A_t = b_0 + b_1P_{t-1} + b_2A_{t-1} + b_3A_{t-2} + b_4Z_t + b_5Z_{t-1} + v_t$.....2.14

Where: $b_o = a_0ß\alpha$, $b_1 = a_1ß\alpha$, $b_2 = (1-ß) + (1-\alpha)$, $b_3 = -(1-ß)(1-\alpha)$, $b_4 = \alpha a_2$, $b_5 = -\alpha a_2(1-ß)$ and

$v_t = \alpha (u_t - (1-ß) u_{t-1})$

The reduced form of the Nerlovian model is an autoregressive model because it includes lagged values of the dependent variable (output) among its explanatory variables. The results indicated a short-run elasticity of + 0.34 and a long-run elasticity of + 0.81,

suggesting that tobacco farmers are highly unresponsive to price changes. The supply function above however loses the effect of the original parameters. The equation could also be a demand function rather than supply function.

Gatete (1993) did an economic analysis of coffee supply in Kenya using a reduced form equation which was derived from structural form functions that underlie the coffee supply. The structural equations were derived from the Nerlovian equations. The standard relationship underlying the supply of coffee are noted as the investment function, the harvesting decision and the vintage production function from which supply function is given as the total output realised per hectare.

The study notes that variations in coffee production from year to year are due to investment done at the farm in the form of new planting, trees damage and the two year bearing cycle (Parikh, 1979). The relationship between potential production and investment in trees is given as;

$$Y^*_t = \sum \sum_{i=0}^{\infty} \delta'(i,t) I_{t-i} \quad \text{.....2.15}$$

Where Y^*_t is the potential production, I_{t-1} is the number of trees planted i years ago which have survived to year t, δ (i,t) is the average yield of these trees.

Assuming that the expected discounted net revenue, V, is given by the following equation;

$$V = \sum_{t=0}^{\infty} (1+r)^{-t} \{(P^*_t - S^*_t) Y^*_t - F_t - f(I_t)\} \quad \text{.....2.16}$$

Where P^*_t is the expected output price in period t, S^*_t is the expected unit cost of harvesting in period t, F_t are the fixed cost in period t, $f(I_t)$ is non linear function of I_t and

represent planting costs in period t necessary to achieve desired output, Y^*_t is the potential output in period t, for t=0,1,.....,∞, and the variable r is the rate of discount.

The equation is maximized with respect to potential output in period t(Y^*_t) and the number of trees in period t(I^*_t) subject to the constraint of a given production function.

The lagrangian function is then constructed as given below;

$$L = \sum_{t=0}^{\infty}\{(1+r)^{-t}[(P^*_t - S^*_t)Y^*_t - F_t - f(I_t)] + \lambda_t(Y^*_t \sum_{i=0}^{\infty}\delta^{'}{}_i i_{t-i})\} \quad \text{.....2.17}$$

The first order conditions for maximization are derived from equation 2.17 and resulting equations are rearranged to give equation 2.18.

$$R^*_t(I) = \sum_{t=0}^{\infty}(1+r)^{-i}(P^*_{t+i} - S^*_{t+i})\delta_i \quad \text{.....2.18}$$

This gives the investment function. The equation states that the investment is continued until marginal cost of investing in one more tree equals the expected discounted net revenue to be obtained from the future production of that tree.

If $f(I_t)$ is a quadratic function of I_t, then $f(I_t) = (\frac{\beta_0}{\beta_1})I_t + (\frac{1}{2\beta_1})I^2_t$ 2.19

Taking the derivative of this equation with respect to I_t and rearranging the equation to solve for I_t results in; $I_t = \beta_0 + \beta_1 R^*_t(I_t)$ giving the investment equation.....2.20

Assuming a constant density of planting d, the acres of new trees in period t, denoted as A^d_t is expressed as; $A^p_t = dI_t$ 2.21

Substituting and rearranging the above equations results to area harvested at period t expressed as; $A^p_t = d\beta_0 + d\beta_1[\sum_{t=0}^{\infty}(1+r)^{-i}(P^*_{t+i} - S^*_{t+i})d_i$ 2.22

Incorporating several modifications, the acreage response equation is given as;

$A^h_t = \alpha_0 + A^h_{t-1} + \alpha_1 P^*_{t-3} + \alpha_2 \delta P_{t-3} + \alpha_3 T_t + D_{t-3} + V_3$.....2.23

Where V_t is a random error term containing measures of uprooted or abandoned trees between planting and harvesting periods. It also gives other stochastic variables. T is time trend and D is the government quotas.

The equation gives the output per hectare in period t. This however would imply that each tree is assumed to produce equal amount of output (coffee) at period t, each hectare would have the same number of trees and that no other variables would affect the output other than prices , government quotas and the effect of time. Given the neglect and poor crop husbandry experienced in coffee industry the output per hectare varies. The current study used the total output of the country within a given year and looking at other variables affecting the supply of coffee to the world market.

Maitha (1972) did an econometric analysis of coffee supply in the Kenyan economy and estimated the price response of coffee growers in Kenya. He argues that a change in acreage does not explain the price effects for annual crops. In some coffee producing areas, he argues, all the suitable land may have long since been devoted to the crop and the only new planting may be merely replacements. With acreage more or less fixed by physical and/or institutional limitations, the cultivators are nevertheless free to vary their inputs and thus both the quantity and quality of the output.

The study's model imposed a constant elasticity of substitution production function and assumed constant returns to scale, and it estimated the parameters of the equation given as;

$$\text{Log}\left(\frac{Q}{A}\right) = a_0 + a_1 \text{Log}\left(\frac{R}{P}\right) \quad \text{.....2.24}$$

Where $\frac{Q}{A}$ is the coffee acreage productivity index, R is the land rent, P is the producers price and a_0 includes the elasticity of substitution, a weather index, an index of technological progress and distribution and substitution parameters

The study expresses the land rent – coffee price ratio in terms of past producers price using Fisher distributed lag form. It therefore estimated elasticity for short run and long run as 0.66 and 0.99 respectively for estates, 0.64 and 0.97 respectively for the small holders and 0.64 and 0.96 respectively for the Kenya supply.

Stewart (1992) studied that global cartels served to artificially bloat the market and, together with the state marketing boards, intervened to distort world prices and prevent smallholders from responding to changes in world demand of coffee, leading to problems of oversupply. Accordingly, it was concluded that coffee reforms have had a substantial impact in countries where the liberalisation process was complete. Uganda is one of the countries where reforms covered the whole marketing chain from farm purchasing to exporting leading to full withdrawal of parastatals from marketing (Oxfam, 2001). This significantly simplified procedures for export licensing and a surge of private traders in the market. The result has been an almost tripling of the target producer price share and large and significant improvement in the immediate transmission of the world market signals. In comparison, Kenya has been accused of pursuing a slow and incomplete reform process, where mandatory auctions are still in place and the Coffee Board of Kenya (CBK) is said to remain highly influential (Karanja and Nyoro, 2002). This is said to have had a detrimental effect because excessive regulation discourages entry of private traders, which in turn curtails competition and obstructs upward movements of the

producers' prices when the world price is high. However, this mainstream analysis of the global coffee industry, which focuses upon the problems of regulation and inefficient government intervention, fails to provide the full story.

Daviron and Ponte (2005) showed that higher levels of price volatility experienced following the end of the price stabilisation mechanisms built into the International Coffee Agreement caused traders to use futures market to minimise their exposure to the risks of price fluctuations by hedging. Small producers were, however, unable to access hedging markets and were therefore exposed to the full volatility of the market, especially following the disbandment of government coffee boards which at least offered some protection (Oxfam, 2001, Luttlinger and Dicum, 2006). The increased activity in coffee futures market had further exacerbated price volatility as a significant portion of paper trade was the result of speculation. As noted by Daviron and Ponte, although the coffee market has always experienced some price volatility, this increase in speculative activity has led to something qualitatively different in the 1990s.

Nyangito (2002) noted that Over 600,000 smallholders were engaged in coffee production and commanded a 48 percent share of the market. Coffee production was on a decline trend since 1987/88 when a record 130,000 Metric tonnes (MT) of clean coffee was produced and then production dropped to an average of 77,514 MT of clean coffee in the year 2000 (ICO, 2006). This was 40 percent less than what was being produced in 1987/88. This means that the country was utilising only 60 percent of the 1987/88 production capacity, which translated to a loss of 51,412 MT of coffee per year. The decline in production was more pronounced in smallholder farms where it declined by 47

percent during the period 1987/88. The smallholder average yields were only half those realised in 1987/88. The low productivity in smallholder farms therefore remained one of the major challenges to be over-come if coffee is to remain a viable farm enterprise (Condliffe, 2008). Although the Nairobi coffee auction prices have remained marginally higher than those prevailing in the international markets, they exhibit the same pattern characterised by declining prices in the last few years.

Zoë (2009) noted that high and medium potential areas, where coffee was initially dominant, had been reduced to small scale farms of up to 0.5 – 10 hectare. 81 percent of small-scale farmers occupied holdings of less than 2 hectares. Considering that the population growth rate is 3.2 percent, the pressure on land is continuously reducing the capacity to sustain food production and cash crop farming as more and more land got transformed to residential centre. The study noted that Kenya however, is one of the few countries in Africa whose agricultural production had kept pace with population growth. Yet, only 15 percent of Kenya's total land area was farmable, and of this only about half was classified as first class land. Most of the good quality farming land was in the Western Highlands, around Lake Victoria and Mount Kenya, and along the coast.

Nyoro (2006) study found out that maize was the principal staple crop that in many areas competed with coffee for land, while wheat production was found not to compete with coffee for land. Other important crops that were competing with coffee for land are millet, cassava, and sorghum. In the year 2005, tea had become the most important cash crop overtaking the traditionally stronger coffee production in export. Tea production grew steadily in the post independence period supported by the increasing prices.

Horticultural products were other production that started replacing coffee due to the rise in their prices. The study found that coffee continued to be an important product for export, but falling prices, repeated droughts and controlled marketing had seriously hurt the sector. The study concluded that coffee production and area under coffee had been on a downward trend as farmers opt for other profitable staple and cash crops. This study used maize prices to capture the effect of the substitute in the supply of coffee to the international market.

Kiptui (2007) investigated the impact of the real exchange rate on the demand for Kenya's exports in an export demand framework which also includes economic activity for Kenya's major export categories: tea, coffee, horticulture and manufactured goods. Bounds testing and ARDL approaches to the analysis of long-run relationships and error correction modelling were applied. The existence of long-run relationships was established for coffee, tea and horticulture exports. The results indicated that the real exchange rate had positive effects in the short-run but the effects are found to be statistically insignificant. Nevertheless, the short-run elasticity was high and positive as in the case of coffee and manufactured goods which were close to unity. The results also confirmed the dominant role played by economic prosperity of the export destination countries and this was demonstrated by significant positive long-run and short-run elasticity. The short-run income elasticity was close to one for tea, horticulture and coffee. The long-run income elasticity was high, ranging from 1.0 for tea to 2.4 for horticulture and 2.8 for coffee. Therefore, the foreign income variable was highly significant and elasticity larger compared to the elasticity of the real exchange rate variable. Therefore the argument that real exchange rate appreciation had adversely

affected exports was not strongly supported by the analysis as increased foreign economic activity dominated as the most important factor explaining export growth. The results however suggested that the effects of the real exchange rate are more likely to be long-run in nature rather than short-term and that there exist threshold levels at which exchange rate fluctuations harm exports.

2.4 Overview of literature

Most of the studies reviewed dealt with internal factors that affect agricultural supply (Leaver, 2003, Asmerom, 1999 and Awudu and Rieder, 2005) and they ignored the external constraints. The nature, magnitude and timing of the variable and the changes they have on the key micro and macroeconomic variables, whose movement can be assumed to track the process of adjustment, should be included in the supply response rather than dwelling on price factor recognition largely ignoring non-price factors like technological growth.

The other issues that have attracted attention of many studies are response of production and export of coffee products to coffee promoting policies and programmes. The studies have empirically investigated the response of farmers to economic incentives in the coffee sector (Stewart, 1992, Karanja and Nyoro, 2002 and Zoë, 2009) and reforms that have been carried out (Gitau, 2009 and Karanja and Nyoro, 2002). Cross sectional data has been used in a number of studies in analysing the response of production to various incentives. This has resulted in the loss of characteristic differences between the variables and therefore estimations could be biased. Since agricultural time series tend to be

trended, regression of trended data, even though giving high $\overline{R}^2$ and significant t-ratios may be spurious, leading to misleading conclusions and recommendations to policy makers (Granger and Newbold, 1974). In addition, while the partial adjustment model is a simple dynamic framework, it's unrealistic assumption of a fixed target supply based on stationary expectations makes it restrictive in the context of optimising behaviour under dynamic conditions (Hallam and Zanoli, 1993)

The current study applied the techniques of Time Series analysis that took into account the dynamics of short run adjustment towards long-run equilibrium in a theoretically consistent manner to come up with coffee supply response.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter contains the model that has been used by the study. Both theoretical and empirical models are presented. The chapter also presents the data type, data sources and data analysis methods

3.2 Research Design

The study estimated a supply function for Kenyan coffee at the international market using the profit maximization model to underpin the supply function theoretically. The study adopted research design which is normative in nature and is non-experimental. This design involves observing the effect of independent variable on dependent variable and to establish the relationship that exists between them. This entailed analyzing data collected from 1974 to 2010 on coffee supply in Kenya using ARDL model.

3.3 Theoretical Model

The farmers' decision to supply is driven by the profit to be obtained from the product. The study therefore used a profit maximization model to obtain a supply function theoretically.

Profit function

Profit function as defined by Varian, (1996) is given as;

$\pi(p, w) = p.y(p, w)) - w.x(p, w)$ 3.1

Where p is the price of output, y is output, x is input and w is the cost of input.

From Hotelling's lemma, the firms net supply function for good i is;

$y_i(p,w) = \frac{\partial \pi(p,w)}{\partial p_i}$ for $i = 1, 2, \ldots n$ 3.2

Considering a case with one output and several inputs and assuming that the derivative exists and that $p_i > 0$, it follows that;

$y(p,w) = \frac{\partial \pi(p,w)}{\partial p}$ 3.3

This is the Hotteling's Lemma supply function.

This implies that optimal output (y*) = $y(p,w)$.....3.4

Where p is the output price and w is a vector of prices of variables inputs.

The objective of the coffee farmers is to maximize the profit earnings from coffee proceeds.

When output price increases by a small amount, farmers will make more profit even at the same level of output and also, price increase will induce farmers to increase output level.

3.4 The Empirical Model

To address objective (i), equation 3.4 was adopted and modified as follows:

$Y_{(t)} = f\{Y_{(t-1)}, P_{c(t-1)}, P_{i(t)}, P_{l(t)}, P_{t(t)}, P_{s(t-1)}, ER_{(t-1)}, R_{(t)}, I_{(t-1)}, W_{(t)}, PE_{(t)}, T_{(t)}\}$.....3.5

Where Y is the supply of coffee, P is price, ER is the exchange rate, R is the market lending rate, I is the rate of inflation, W is the level of rainfall, PE is the policy effect and T is the time trend. The variables are further defined in section 3.5 below.

The estimated model therefore was given as;

$$Y_{(t)} = \beta_0 + \beta_1 Y_{(t-1)} + \beta_2 P_{c(t-1)} + \beta_3 P_{i(t)} + \beta_4 P_{l(t)} + \beta_5 P_{t(t)} + \beta_6 P_{s(t-1)} + \beta_7 ER_{(t)} + \beta_8 R_{(t)} + \beta_9 I_{(t-1)} + \beta_{10} W_{(t)} + \beta_{11} PE_{(t)} + \beta_{12} T_{(t)} + \varepsilon_t \quad \ldots\ldots 3.6$$

Where ε_t is error term. The equation was estimated in ARDL model using OLS.

To address objective (ii) the Error Correction Model was utilized in order to comment on the error correction term. The ECM was presented as:

$$\Delta y_t = \beta_0 + \beta_1 \Delta x_{it} + \sigma \varepsilon_{t-1} + \varepsilon_t \quad \ldots\ldots 3.7$$

This was the ECM for coffee supply with x_{it} representing all the exogenous variables at period t and $\sigma \varepsilon_{t-1}$ representing the lag of error term. $\sigma \varepsilon_{t-1}$ in equation 3.8 provides the error correction mechanism.

3.5 Definition, Measurement of Variables and Working Hypothesis

$Y_{(t)}$ represents the level of coffee output measured by the annual output in metric tons as reported by the Coffee Board of Kenya.

P_c is the world coffee prices per metric ton in a given year and in US dollars per metric ton. It was assumed that the increase in world prices of coffee affected the supply of coffee positively.

P_i is the average cost of inputs. This gave the average cost of producing one metric ton of output as given by the CBK. The cost was in Kshs. It was assumed that the cost of inputs affects the level of supply negatively.

P_l represents average cost of land in a given period along the coffee growing areas. This captured the effect of demand for land for other purposes other than farming in agricultural land. The areas previously used for farming coffee have been transformed to settlement areas as demand shifts. The average cost was assumed to affect the supply of coffee in a negative way as coffee competes with other products for land. Measurement was given in Kenya shillings per acre as supplied by the Ministry of Land.

P_t is the average cost of handling coffee from the farm to the world market. This captured the effect of services offered by the middlemen, cost of transportation and coffee handling charges. The measurements ware in Kenya shillings per metric ton as supplied by the CBK. The hypothesis was that the transactions cost affected the supply of coffee negatively.

P_s stands for the world price for substitute. Maize was assumed to compete with coffee for land in Kenya. As prices for maize increased, farmers are assumed to shift from using land for growing coffee to growing maize. Therefore the prices for maize were used to capture the effect of substitute and the relationship was assumed to be negative. The measurements were given in Kenya shillings per metric ton as provided by the Ministry of Agriculture.

ER is the exchange rate. Exchange rate affects the profit that farmers earn. This is because the supply of coffee is paid in dollars but this is converted to local currency whose level depends on the existing exchange rates. The exchange rate affects the supply positively as exports are positively affected by the currency depreciation. The

measurements are the average nominal rate in Kenya shillings per unit of US dollar in a given year as provided by Kenya National Bureau of Statistics (KNBS).

R represents the average level of interest rates that prevailed in the market. This captured the capacity of a farmer to borrow either from a Sacco or commercial banks. With access to financial facilities, the farmers were assumed to increase the level of output. Therefore, level of interest rates prevailing in the market was assumed to affect the supply negatively. The interest rates data was captured from the Central Bank of Kenya.

I, is the inflation. This was the rise in general price levels measured by the difference between the consumer price index (CPI) of a given period from that of the previous period. Since the supplier will be interested in the real money, inflation was assumed to effect supply negatively. The inflation data was provided by KNBS.

W is the weather conditions. Coffee grows under wet conditions. W therefore was a dummy representing 0 for periods with rainfall less than 1000 mm and 1 for periods equal to 1000 mm or more. The data for weather was from Kenya metrological department and captured the average rainfall from Kenya coffee growing zones in a given period.

PE is a dummy representing the effect of policies. The dummy was 1 for the period preceding reforms and 0 otherwise. Therefore for period 1974 to 1992 was 1 and 0 for periods 1993 to 2010.

T represents the trend which captured the change in technology and other omitted variables. Thus the sign was expected to be either a negative or a positive sign depending on whether there was a decrease or an increase in technological change and the effect of those omitted variables in the supply function.

3.6 Data Type and Source

Published data was utilized in the study. The data was collected from the Coffee Board of Kenya (CBK), Kenya National Bureau of Statistics (KNBS), Kenya Tea Development Authority, Kenya Metrological Department, Ministry of Science and Technology and Central Bank on Kenya. Where data source was not complete information, other sources were consulted and necessary corrections affected to maintain consistency.

3.7 Data Analysis

The data collected was time series and had trends. To avoid spurious regression results, stationary and cointegration tests were conducted on the series. Each series was tested for the presence of unit root using Augmented Dickey Fuller (ADF) and Philips Peron (PP) test. If the unit root was confirmed, the series was made stationary by differencing.

Once the test for unit root was carried out, variables with 1(0) and 1(1) were included in the estimation of the model. The study also explored the existence of a cointegration relationship among the variables in equation 3.7 based on the standard cointegration techniques. Tests for cointegration of the variables using Johansen Cointegration Test were carried out. Where cointegration was confirmed, a long-run relationship among the variables existed.

The supply function for coffee was estimated in Autoregressive Distributed Lag (ARDL) Model. The variables were expressed in logarithmic form and then the supply equation estimated to address objective one. To address the second objective, ECM was constructed. Based on Granger representation theorem, if sets of variables are cointegrated, the short-run dynamics of the long-run equilibrium can be described by an Error Correction Model (Engle and Granger, 1987, Maddala, 2000 and Gujarati, 1995). To test for normality, Jarque-Berra statistics were carried out, ARCH residual test for homoskedasticity and LM test for autocorrelation.

CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

This section presents data analysis and interpretation. The section gives the data test for unit root, log liner model results, test for cointegration and error correction model results.

4.2 Unit root tests

Most of the time series data are known to be non-stationary and analysis of such data without correcting for non-stationarity can lead to spurious correlation. Since the data used in this study is a time series one, stationarity tests were done to establish whether the data are stationary or not and also to determine the order of integration of variables. The unit root tests were done using Augmented Dickey Fuller Test (ADF) and Philips Peron (PP) tests. The unit root results are as shown in table 4.1 below;

Table 4.1 Unit root tests at levels.

Va nriables	ADF Statistics	ADF Critical Values	Philips Peron Statistics	Philips Peron Critical value	Conclusion
Log ER	-1.127331	1% = -3.6289 5% = -2.9472 10%= -2.6118	-0.919885	1% = -3.6228 5% = -2.9446 10%=-2.6105	Not stationary
Log R	-1.610466	1% = -3.6289 5% = -2.9472 10%= -2.6118	-1.946793	1% = -3.6228 5% = -2.9446	Not stationary

				10%=-2.6105	
Log I	-3.843923	1% = -3.6289 5% = -2.9472 10%= -2.6118	-4.232490	1% = -3.6228 5% = -2.9446 10%=-2.6105	Stationary
Log P_c	-3.054595	1% = -3.6289 5% = -2.9472 10%= -2.6118	-2.897744	1% = -3.6228 5% = -2.9446 10%=-2.6105	Stationary
Log P_t	-1.953115	1% = -3.6289 5% = -2.9472 10%= -2.6118	-1.599131	1% = -3.6228 5% = -2.9446 10%=-2.6105	Not stationary
Log P_i	-1.572311	1% = -3.6289 5% = -2.9472 10%= -2.6118	-2.002228	1% = -3.6228 5% = -2.9446 10%=-2.6105	Not stationary
Log P_l	-0.271488	1% = -3.6289 5% = -2.9472 10%= -2.6118	-0.036982	1% = -3.6228 5% = -2.9446 10%=-2.6105	Not stationary
Log P_s	-0.703358	1% = -3.6289 5% = -2.9472 10%= -2.6118	0.762815	1% = -3.6228 5% = -2.9446 10%=-2.6105	Not stationary
Log Y	-1.160484	1% = -3.6289 5% = -2.9472 10%= -2.6118	-1.295248	1% = -3.6228 5% = -2.9446 10%=-2.6105	Not stationary

Application of ADF and PP tests to the variables under investigation shows that only Log of coffee prices and Log of Inflation are stationary (I(0)) and the other variables are found to be non-stationary. There is therefore the need to find the order of integration for the other variables. Table 4.2 shows the other variables to be first order autoregressive processes (AR(1)). The table indicates that the hypothesis of unit root is rejected at 1% significance level at the first difference.

Table 4.2: Unit root tests at first difference

Variables	ADF Statistics	ADF Critical Values	Philips Peron Statistics	Philips Peron Critical value	Conclusion
Log ER	-2.954315	1% = -3.6353 5% = -2.9499 10%= -2.6133	-4.027124	1% = -3.6289 5% = -2.9472 10%=-2.6118	Stationary
Log I	-5.649094	1% = -3.6353 5% = -2.9499 10%= -2.6133	-6.221335	1% = -3.6289 5% = -2.9472 10%=-2.6118	Stationary
Log P_t	-4.913188	1% = -3.6353 5% = -2.9499 10%= -2.6133	-5.415723	1% = -3.6289 5% = -2.9472 10%=-2.6118	Stationary
Log P_i	-3.448374	1% = -3.6353 5% = -2.9499 10%= -2.6133	-5.311063	1% = -3.6289 5% = -2.9472 10%=-2.6118	Stationary
Log P_l	-3.652724	1% = -3.6353 5% = -2.9499 10%= -2.6133	-4.944002	1% = -3.6289 5% = -2.9472 10%=-2.6118	Stationary
Log P_s	-5.566530	1% = -3.6353 5% = -2.9499 10%= -2.6133	-7.175844	1% = -3.6289 5% = -2.9472 10%=-2.6118	Stationary
Log Y	-6.491327	1% = -3.6353 5% = -2.9499 10%= -2.6133	-9.4335976	1% = -3.6289 5% = -2.9472 10%=-2.6118	Stationary

After making the series to be stationary, the log-linear model given in equation 3.7 is estimated in the ARDL. The regression results are given in table 4.3

Table 4.3: Regression results for the Log-linear model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Difference of log of output at previous period	-0.266496	0.102671	-2.595624*	0.0173
Log of output prices at previous period	0.032362	0.071159	0.454782	0.6542
Difference of log of inputs cost	-0.307364	0.107577	-2.857149*	0.0097
Difference of Log of land cost	-0.012961	0.073252	-0.176939	0.8613
Difference of Log of handling coffee	-0.353588	0.122722	-2.881222*	0.0092
Difference of Log of cost of substitute in the previous period.	0.056760	0.090271	0.628782	0.5366
Difference of Log of exchange rates in the period.	0.387628	0.241577	1.604568	0.1243
Difference of Log of interest rates.	0.025576	0.110327	0.231818	0.8190
Log of inflation in the previous period	-0.022847	0.043848	-0.521039	0.6081
Weather	-0.159113	0.062594	-2.541983*	0.0194
Policy Effects	-0.190553	0.088445	-2.154479*	0.0436
Trend	-0.007230	0.004496	-1.607988	0.1235
Constant	0.322560	0.184932	1.744212	0.0965
R-squared	0.841016	Mean dependent var		-0.012674
Adjusted R-squared	0.729728	S.D. dependent var		0.227299
S.E. of regression	0.118168	Akaike info criterion		-1.135899
Sum squared resid	0.279272	Schwarz criterion		-0.469321
Log likelihood	34.87823	F-statistic		7.557071
Durbin-Watson stat	1.560093	Prob(F-statistic)		0.000032

Asterisk represents significance at 5 per cent level of confidence

Breusch-Godfrey Serial Correlation LM Test (Appendix V) was generated to test whether the model contains autocorrelation. The hypothesis that the log linear model has a serial correlation was rejected. The model also passed the Jarque-Bera statistics tests for normality (Appendix III) and ARCH residual test for homoschedasticity (Appendix IV).

The adjusted R-squared of 0.729728 indicates that about 73 percent movement in coffee supply from Kenya to the international market is explained by changes in the variables

studied. These variables are; previous period coffee output, previous period international coffee prices, price of inputs, price of land, cost of handling the coffee, previous prices of substitutes, previous period exchange rates, banks lending rates, previous period level of inflation, weather, government policies and technology. The model also used the periods 1979 and 1984 as dummies so as to test whether the two periods are statistically different from zero. This is because the two periods portrayed high residue as show by residual plot in appendix viii. The unexplained variations (27 percent) may be explained by the economic conditions prevailing in the importing countries and the changing taste and prevalence.

From the log-linear model presented in table 4.3, the difference of log of previous period coffee output, difference of log of inputs, difference of the log of cost of transaction for coffee, policy effects and weather were found to be statistically significant at 5% level of significance.

4.3 The determinants of supply of Kenyan coffee to the world market.

The change of log of output from the previous period is statistically significant at 5 percent level of significance. The series of log of coffee output has a unit root as shown by table 4.1 and is differenced to make it stable. The negative coefficient of this variable implies that the previous period level of production of coffee affects this period level of output negatively. If there has been coffee inventory or if high supply was realised during the previous period, the supply for the current period would be affected negatively.

The log of international coffee price is positive and statistically insignificant. This can be explained by the fact that producers are more concerned with the real price they receive but not the international prices as explained by Asmerom (1999). The elasticity of coffee supply with respect to the international price is given as 0.03.

The cost of inputs series was found to have a unit root but stationary at 1(1). The variable was used to capture the cost of fertilizers, cost of manure, insecticides and labour cost. The variable was found to be statistically significant at 5 percent level. This shows that suppliers respond to the change in the cost of inputs negatively. The elasticity of supply of coffee to the cost of inputs is 0.31. The coefficient is negative as expected indicating that as cost of input rises, the amount of Kenyan coffee supplied to the international market declines. This therefore supports the study by Karanja and Nyoro (2002).

The log of cost of land series is I(1). The variable was used to estimate the effect of land demand for other purposes on the production of coffee. The variable is statistically insignificant. It was measured by the movement of cost of land in Kenya over the years. This means that the change of cost of land in Kenya does not seem to significantly affect the supply of Kenyan coffee to the international market. This is contrary to Zoë (2009) study that noted that high and medium potential areas, where coffee was initially dominant, had been reduced to small scale farms of up to 0.5 – 10 hectare as the population growth put pressure on the land continuously reducing the capacity to sustain food production and cash crop farming as more and more land got transformed to residential use. The supply of coffee to the world market is inelastic (0.01) to the cost of

land. The effect is negative as expected implying that as the cost for land increases, the supply of coffee supplied to the international market reduces.

The cost handling coffee was used to capture the effect of middlemen, infrastructure, cost of transportation and marketing from Kenya to the international market. The variable was found to be statistically significant at 5 percent level and negatively related to the coffee supply. The series for cost of handling coffee is I(1). Elasticity of coffee supply to the international market with respect to the handling cost was found to be -0.35. This means that as the cost increases, the amount of coffee supplied reduces. This is in agreement with the studies by Stewart (1992) and Oxfam, (2001) who said that middlemen and poor infrastructure just distort the market for coffee.

To capture the effect of substitutes for coffee, the price for maize was used since maize is known to compete with coffee for land in Kenya. The log of the series for maize prices was found to be I(1) and statistically insignificant. The changes of price of maize therefore do not have any significant effect on the supply of coffee in Kenya. This is inconsistent with Nyoro (2006) whose study found that coffee competes with maize for land and that farmers are replacing coffee plantations with maize as the price of the former goes down. The coefficient of 0.06 for the substitute indicates inelasticity and is positive. The study therefore implies that as price of maize increases, the supply of coffee to the international market is not significantly affected. The positive sign to the coefficient means that the gains from maize produce are used to increase the coffee output.

Exchange rate series was found to be have a unit root but stationary at I(1). The variable is not statistically significant and is negative. This shows that the variations in exchange rates do not have effect on the supply of Kenyan coffee to the world market. This supports Kiptui (2007) whose findings were that the real exchange rate had negative effects and the effects are found to be statistically insignificant. The negative sign means that the benefits that the suppliers would derive from the local currency devaluation are swept off by the cost of inputs that happen to be imported.

The change of log of interest rates is statistically insignificant. This indicates that the lending rates prevailing in the country do not affect the level of coffee supplied to the international market. The amount of the supply of coffee from Kenya to the international markets is also inelastic (0.03) to the lending rates prevailing in the country. Therefore changes in the level of lending rates to farmers by the commercial banks may not have a statistically significant influence on the level of coffee supply. The relationship is positive against the theory implying that as lending rates from the commercial banks increase, so does the level of coffee supply to the international market. This may be explained by the fact that the large scale farming of coffee is mainly practised by the foreigners who take advantage of higher interest rates differential between the countries to invest.

Logarithms of inflation series are found to be I(0) and statistically insignificant at 5 percent level. The amount of the coffee supply from Kenya to the international markets is also inelastic (-0.02) to the level of inflation prevailing in the country. The negative sign

means that the inflation prevailing in the economy affects the level of coffee supply negatively.

The dummy variable for weather is statistically significant at 5 percent level. Since the variable is a dummy, it shows that the amount of rainfall experienced in the coffee growing areas gives rise to a significant difference in the level of coffee supply.

The government policy on coffee is a dummy variable and is statistically significant at 5 percent level. The government policies applied to the supply and production of coffee from the year 1992 therefore had a significant difference to the amount of supply of Kenyan coffee to the international market. This is in agreement with the study by Karanja (2004) that said the reform period has been accompanied by under capacity utilisation in coffee processing and milling, factors that do not augur well for the farmers' returns.

Trend effect is statistically insignificant. The coefficient is negative indicating that the new technology aimed at increasing supply has not been embraced by the farmers.
Table 4.4 shows the variables that were found to be cointegrated and therefore meaning that there is a long run relationship among these variables.

Table 4.4: cointegration tests.

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.840205	159.0484	124.24	133.57	None **
0.603295	93.02942	94.15	103.18	At most 1
0.445246	59.74518	68.52	76.07	At most 2
0.415826	38.53287	47.21	54.46	At most 3
0.294439	19.18085	29.68	35.65	At most 4
0.166882	6.625429	15.41	20.04	At most 5
0.001459	0.052565	3.76	6.65	At most 6
*(**) denotes rejection of the hypothesis at 5%(1%) significance level				

The results of cointegration test shows that there exist five cointegrating relationship. The variables Coffee output, Handling cost, Price of substitute, Price of inputs, International Coffee prices and inflation are cointegrated and therefore there exists a long-run relationship among them. The results show that even though the following variables, handling cost, price of substitute, price of inputs, international coffee prices and inflation deviate so much from the long run trend, they still trace coffee output. Therefore influencing these variables to achieve the desired level of coffee supply could be beneficial in the long run.

4.4 The short run and long run elasticity of supply

Given the cointegrating variables, it is important to examine the short run and long run effect of these variables. The long run regression results indicate that constant, cost of inputs, international coffee prices and interest rates are statistically significant at 5 percent level. The results are given in table 4.5.

Table 4.5 Long-run Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	4.835660	0.123547	39.14040	0.0000
Cost of inputs	-0.338801	0.101472	-3.338861	0.0023
Cost of transaction	-0.201388	0.178024	-1.131242	0.2669
International coffee prices	0.144993	0.069794	2.077443	0.0464
Inflation	-0.041292	0.045009	-0.917421	0.3662
Interest rates	0.243258	0.071331	3.410256	0.0019
Exchange Rate	0.280928	0.154717	1.815746	0.0794
R-squared	0.819565	Mean dependent var		4.867521
Adjusted R-squared	0.783479	S.D. dependent var		0.141693
S.E. of regression	0.065932	Akaike info criterion		-2.431715
Sum squared resid	0.130412	Schwarz criterion		-2.126947
Log likelihood	51.98674	F-statistic		22.71088
Durbin-Watson stat	1.307006	Prob(F-statistic)		0.000000

The error correction model results that also give the short run variables' coefficients are given in table 4.5. The coefficients found to be significant at 5 percent level were for the cost of inputs, cost of handling coffee, exchange rates and the error correction term.

Table 4.6 Error Correction Model Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Difference of cost of inputs	-0.469473	0.097948	-4.793072	0.0000
Difference of cost of transactions	-0.333543	0.121509	-2.745008	0.0103
Difference of international coffee prices	0.009921	0.073794	-0.134447	0.8940
Difference of inflation	-0.008504	0.028931	-0.293958	0.7709
Difference of interest rates	0.168089	0.095313	1.763542	0.0883
Difference of exchange rates	0.519814	0.172774	3.008644	0.0054
RESIDUAL(-1)	-0.621289	0.157068	-3.955551	0.0005
R-squared	0.781391	Mean dependent var		-0.006505
Adjusted R-squared	0.736161	S.D. dependent var		0.097479
S.E. of regression	0.050070	Akaike info criterion		-2.978104
Sum squared resid	0.072705	Schwarz criterion		-2.670198
Log likelihood	60.60588	F-statistic		17.27612
Durbin-Watson stat	1.862108	Prob(F-statistic)		0.000000

The error correction term is stationary. This shows that there exists cointegrating relationships between the exogenous and the endogenous variables.

The cost of inputs with a standard error of 0.097948 is statistically significant at 1 percent level. In the short and long run, real cost of inputs has a significant negative impact on the level of coffee supplied to the international market

.

The cost of transactions that farmers face from the farm to the consumer of coffee is statistically significant at 5 percent level. The standard error is 0.121509 and t-statistic of -2.745008. The cost of transaction therefore impacts negatively, both in the short run and

long run effect, the supply of coffee from Kenya to the international market.

The international price of coffee variable is statistically insignificant even at 10 percent level. There is a positive but insignificant impact of international coffee prices both in short run and long run to the supply of Kenyan coffee to the international market.

Inflation variable is statically insignificant both in the short and long run. This means therefore that the amount of coffee supplied to the international market from the country is not significantly influenced by the level of inflation prevailing in the economy.

The rate of lending by the commercial banks is statistically significant at 5 percent level, in the long run. It is, however, significant at 10 percent level in the short run. The meaning of this is that the level of coffee supply from Kenya to the international market is influenced positively by the local banks level of lending rates. This goes against the theory. This may be from the reason that large coffee farming is done by foreigners.

Exchange rate is statistically significant at 5 percent level of significance in the short run but statistically significant at 10 percent level in the long run. It impacts positively on the level of coffee supplied both in the short and long run.

The error correction term is statistically significant at 5 percent level. The coefficient shows the speed of adjustment. The speed of adjustment to the long run equilibrium is -0.62 percent. The supply of coffee at each period adjusts to its long run equilibrium by reducing

the disequilibrium level of supply by 0.62 percent.

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY IMPLICATIONS

5.1 Introduction

This chapter presents summary of the findings of this study as well the conclusions drawn from the findings. It also presents suggestions on the way forward in the light of findings and conclusions.

5.2 Summary and conclusions

The study sought to identify the determinants of coffee supply from Kenya to the international market. The study analysed the effect of twelve variables on the supply of coffee from Kenya to the international market. The current prices of coffee offered at the international market do not seem to have significant effect, both in the long run and short run, on the amount of coffee supplied from Kenya. This explains why the increase of the international prices for coffee does not seem to stimulate production from Kenya. With insignificant effect of international prices on the supply of coffee from Kenya, the exchange rate equally has insignificant effect in the short run but becomes statistically significant in the long run. This is unlike many studies that indicated that prices offered by consumers of coffee have effect on the level of coffee supplied and that exchange rate policies may automatically lead to improved supply in the short run. This would therefore mean that the internal factors play a major role in influencing the amount of Kenyan supplied to the international market more in the short run than in the long run.

With policy effect being statistically significant at 5 percent level, it means therefore that the economic incentives and policy changes by the government do have significant impacts on coffee supplied for export. The policy reforms undertaken from the year 1992 have had significant effects on the supply of coffee. This has been witnessed by the liberalisation of the sector that has resulted to some extent in politicisation of cooperatives, rise of corruption in the sector, splitting of the coffee cooperative societies eroding on producers' economy of scale, under capacity utilisation in coffee processing and milling which erode the farmers returns, and cartel formation leading to exploitation of the farmers. On the other hand, the liberalisation of the sector has brought increased competition in the sector and producers participation in marketing of the produce.

The cost of land in Kenya was found to be statistically insignificant. Although the cost of land has been exponentially increasing and demand for land for other uses like residential centres has also been growing, this does not seem to influence the level of coffee supplied significantly. This therefore goes against the populist belief that agricultural land initially used for coffee has been transformed to residential areas as the demand for the latter grows. Also inflation does not affect the level supplied significantly. This is despite the fact that suppliers would be interested in the real money and what it can buy once paid for the supply.

A meaningful conclusion from this study is that the cost of inputs and cost of handling coffee from the farms to the consumers significantly affects the supply both in short and long run. This implies that as the cost of inputs rises, the amount of coffee supplied from Kenya to the international market reduces. The reduction effect reduces in the long run.

The coefficient for cost of handling coffee from the farms to the international market is negative and statistically significant in the short run and in the long run. This implies that the change in the cost of handling has a negative effect on the level of coffee supplied. Farmers will respond to changes in the cost of transportation, charges by the middlemen, coffee miller charges and cost of cooperatives subscription (which are the component of handling cost) negatively.

The amount of coffee supplied in the previous period affects the current period's supply significantly. The coefficient for the previous period amount of coffee supplied is negative. This means that there is the need to control the level of output that will spill over to the next season.

The trend is statistically insignificant implying that there has not been significant change on the level coffee output over the period under the study. Farmers seem not to have significant changed the level of output that would have otherwise come as a result of modern and efficient methods of farming. This would have brought an increase in the output levels of coffee from farming the same acreage over the years. This is more so from the small scale farmers who account of 48 percent of the total supply from Kenya.

The dummy variable for weather is statistically significant. The amount of rainfall received in the coffee growing areas therefore affects the level of coffee supplied. The exchange rate is significant in the short run. This means that the exchange rate prevailing will have an

immediate effect on the level of coffee supplied to the international market.

The study therefore concludes that the cost of handling coffee from the farms to the international market and cost of inputs affect the supply of Kenyan coffee to the international market both in the long run and short run while weather and the government policies have a significant effect to the volume of coffee supplied to the international markets from Kenya in the long run. In the short run, exchange rate and the error term also affect the amount supplied.

5.3 Policy Implications

Following the findings of this study, the following are the policy recommendations;

It was found that the cost of inputs affects the supply of coffee significantly. There is therefore a need to look at these inputs and their prices. Reviewing down the prices through subsidies will result in increase in the level of coffee supplied. The drop in prices of inputs will stimulate increased supply of coffee to the international market.

Cost of transaction included the transport cost, the cost of middle men, costs to the coffee societies, cost of marketing and taxes. This means therefore that improved road networks in the coffee producing areas reduces the cost of transportation, reducing the number of middlemen, combining the societies to take the advantage of economy of scale, optimum management of coffee factories, capacity utilisation of coffee processing and milling

organisation and elimination of cartels in the industry will result in reduction of the cost of handling coffee from farms to the market. This will stimulate increased supply of coffee to the market.

The marketing of the coffee produce should be done to avoid keeping inventories. The output for any given period should be fully marketed and exhausted to avoid accumulation and this therefore will make the present period output of coffee to face the real demand prevailing in the market. Forward market facilities in the coffee world market should be utilized to warn farmers from price fluctuation.

The policies changes effected by the government since the year 1992 have significant effect. These policies need to be enhanced and re-evaluated to mitigate on the negative effects that they might have caused. This includes addressing the negative effect experienced by liberalisation. This could be by making sure that the coffee cooperative societies do not split to uneconomical units and making sure that the proper crop husbandly is practiced. This may well influence the prices the producers get and therefore stimulating increased supply of coffee to the word market.

Availability of irrigation water and use of modern and effective methods of farming need to be embraced by the farmers need to be encouraged to mitigate on the negative effects resulting from bad weather. With proper farming methods, increased production from the same number of coffee trees would be experienced thereby increasing the level of supply. Farmers therefore should be trained on the modern methods of farming.

5.4 Limitations of the study and suggestions for further research

This study utilized the entire country's data for the coffee supplied to the international market. This leaves further research on the supply from the small scale farmers and supply from the estates. Study on the local demand for the product can also give further insight on the volume produced locally. Economic conditions of the export destinations also need to be studied. This would show whether changing economic conditions like income, policies and political conditions do have an effect to the local supply of coffee to the word market.

REFERENCES

Askari, H. and J. Cummings, 1976. *Agricultural Supply Response*: *A survey of the econometric evidence.* New York: Praeger.

Askari, H. and J. Cummings, 1977. *Estimating Agricultural Supply Response with the Nerlove Model: a survey.* International economic review 18(2): 257-292.

Asmeron, K., 1999. *Real Exchange Rate Price and Agricultural Response in Ethiopia*: *A case of perennial crops. Research paper 99, Nairobi*: African Economic Research Consortium.

Awudu, A. and P. Rieder, 2005. *The Impact of Agricultural Price Policy on Cocoa Supply in Ghana*: *An Error Correction Estimation.* Journal of African Economic. Volume 4, Number 3, pp 315 – 35.

Buss, G., 2010. *Economic Forecasts with Bayesian Autoregressive Distributed Lag Model*: Choosing optimal prior in economic downturn. Journal of applied mathematics, volume 111 number 3.

Condliffe, K., 2008. Kenya Coffee: *A Cluster Analysis Harvard Business School. Prepared for presentation at the African Econometric Society Conference*. Cape Town

Daviron, B. and S. Ponte, 2005. *The Coffee Paradox: Global Markets, Commodity Trade and the Elusive Promise of Development*. London: Zed Books.

Dickey, D. and W. Fuller, 1982. *Distribution of the Estimators for Autoregressive Time Series with a Unit Root.* Journal of American Statistical Association. Volume 10

Engle, R. and C. Granger, 1987. *Cointegration and Error Correction: Representation, estimation and testing.* Econometrica, 55

Export Processing Zones Authority, 2010. *Tea and Coffee industry in Kenya*. Nairobi: International Research Network

Gatete, K., 1993. *Economic Analysis of Coffee Supply in Kenya.* Columbia: University of British.

Gitau, 2009. *Agricultural Policy-Making in Sub-Saharan Africa: Kenya's Past Policies. Nairobi:* Tegemeo Institute of Agricultural Policy and Development.

Granger, C. and P. Newbold, 1974. *Spurious Regression in Econometrics*: Journal of Econometrics. 2;111-20

Gujarati, D., 1995. *Basic econometrics. 3rd edition*. New York: McGraw-Hill.

Hallan, D. and R. Zanoli, 1993. *Error Correction Models and Agriculture supply response. European Review of Agricultural Economics.*151-66

International Coffee Organization, 2006. *Exports by exporting countries to all destinations. Available at* http://www.ico.org/trade/m1.htm (Accessed on 30th May 2011)

International Coffee Organization, 2009. *Indicator Prices, Monthly and Annual Averages. Available at www.ico.org/coffee_prices.asp.* (Accessed on 30th May 2011)

Johnston, J., 1972. *Econometric Methods. 2nd Edition.* New York: McGraw-Hill.

Karanja, M., 1998: *Effects of Liberalisation Measures Undertaken in the Coffee Industry on Coffee Production, Quality and Profitability in Kenya.* Kenya Coffee, volume 63 number 743

Karanja, A. and J. Nyoro, 2002. *Coffee Prices and Regulation and their Impact on Livelihoods of Rural Community in Kenya.* Nairobi: Tegemeo Institute of Agricultural Policy and Development.

Karanja, A., 2004. Policy Notes: *Coffee Sub-Sector in Kenya.* Nairobi: World Bank.

Kenya National Bureau of Statistics, 2007. *Kenya Statistical Abstract.* Nairobi: Government Printer

Kiernan, J., 1969. The *Origins of Arabica Coffee Production in East Africa.* African Historical Studies Vol 2, No 1.

Kinoti, J., 2005. *Opportunities for Investment in the Coffee Sector.* Presentation to the USA-Africa Business Summit in Baltimore. Kenya Coffee Board.

Kinoti, J., 2005. *Opportunities for Investment in the Coffee Sector.* Presentation to the USA-Africa Business Summit in Baltimore, Kenya Coffee Board.

Kiptui, M., 2007. *Does the Exchange Rate Matter for Kenya's Exports? A Bounds Testing Approach;* Prepared for presentation at the African Econometric Society Conference. Cape Town

Leaver, R., 2003. *Measuring the Supply Response Function of Tobacco in Zimbabwe.* Paper presented at the 41st Annual Conference of the Agricultural Economic Association of South Africa. Pretoria: South Africa

Lewin, B., D. Giovannucci and P. Varangis, 2010. *Coffee Markets: New Paradigms in Global Supply and Demand.* New York: World Bank.

Luttlinger, N. and G. Dicum, 2006. *The Coffee Book: Anatomy of an Industry from Crop to the Last Drop.* New York: New York Press.

Maddala, G., 2001. *Introduction to Econometrics. 3rd ed. Sussex*, United Kingdom: John Wiley and Sons Ltd.

Maitha, J., 1972. *Coffee in the Kenya Economy. An econometric analysis*. Nairobi: East African Bureau.

Nerlove, M. and W. Addison, 1958. *Statistical Estimation of Long run Elasticity of Supply and Demand*. Journal of farm economics, 40, 861 - 880

Nerlove, M., 1958. *The dynamics of supply: Estimation of farmers' response to price.* Baltimore, New York: The Johns Hopkins Press.

Nerlove, M., 1979. *The dynamics of supply: Retrospect and prospect.* American journal of agricultural economics 61(5), 874-888.

Njoroge, J., 2001. *Advances in Coffee Agronomy*. Proceedings of the International Scientific Symposium on Coffee. Bangalore, India, pp. 104–119.

Nyangito, H., 2000. *Delivery of Services to Smallholder Farmers and Impacts on Production under Liberalization in Kenya.* Discussion Policy Paper No. 2. Nairobi: KIPPRA.

Nyangito, H., 2001. *Policy and Legal Framework for the Coffee Sub-sector and the Impact of Liberalization in Kenya.* Discussion Policy Paper No. 3. Nairobi: KIPPRA

Nyoro, J., J. Ariga, And T. Jayne, 2006. *Factors Driving Growth in Fertilizer Consumption in Kenya.* Tagemeo Working Paper, No 24.

Ojambo, F., 2010. *Kenya Export Growth Areas and Crop Farming. Global Agricultural Information Network Distribution. Available at: htt:/www.nations encyclopedia.com* (accessed on 8th may 2011)

Oxfam International, 2008. Coffee Talk: *Fair trade certified coffee. Oxfam International website.http://www.oxfamamerica.org/newsandpublications/news_updates/archive2004/art6877.html*. (Accessed on 30th April 2011).

Oxfam, 2001. *The Coffee Market: A Background Study*. New York: Oxford

Perkh, A., 1979. *Estimation of Supply Functions for Coffee: Applied economics* 11:23-43

Ponte, S., 2002a. *Brewing a Bitter Cup? Deregulation, Quality and the Re-organisation of Coffee Marketing in East Africa: Journal of Agrarian Change* 2 (2) 248-272

Ponte, S., 2002b. The *Latte Revolution, Regulation, markets and consumption in the global coffee chain: World development journal*, 30 (7), 1099–1122.

Sau-Him, P., 2004. *Using an Error Correction Model to Test Whether Endogenous Long-run Growth Exists*. Hong Kong: University of Hong Kong.

Stewart, R., 1992. Coffee*: The Political Economy of an Export Industry in Papua.* New Guinea: West view Press.

Varian, H., 1996. *Intermediate microeconomics*: *a modern approach. 4th edition*. New York: W.W. Norton and Company.

Zoë, P., 2009. *The Poverty of Development Ideas*: *The Political Economy of Kenya's Coffee Industry.* Leicester: University of Birmingham

APPENDICES

APPENDIX I

Table AI: Raw data

Year	Y (Tonnes)	P_c (USD)	P_s (Kshs)	Er (Kshs/ USD)	Inf (%)	R (lending rates)	P_i (kshs)	P_t (Kshs)	W (mm)	P_l (Kshs per acre)
1974	72,016	1.3	35	7.4	16.3	4.4	1.0	3.8	916	500
1975	65,449	1.3	42	7.4	17.8	6.2	1.4	3.7	1,433	500
1976	73,810	3.0	63	7.4	10.0	5.6	1.9	9.1	861	500
1977	97,345	5.3	69	7.4	12.7	2.2	2.3	15.8	1,693	500
1978	81,429	3.5	80	7.4	12.6	4.2	3.1	10.2	1,055	500
1979	72,888	3.6	70	7.4	8.4	6.1	2.8	10.6	1,156	500
1980	91,009	3.4	80	7.4	12.8	5.3	3.6	10.7	1,008	500
1981	98,751	2.5	86	9.1	12.7	7.6	4.8	11.1	1,086	800
1982	86,923	2.5	90	11.0	22.4	12.8	4.3	14.2	7,765	850
1983	85,450	2.6	96	13.4	14.6	14.6	5.4	18.8	1,307	950
1984	128,941	2.7	139	14.5	9.1	13.8	5.9	21.0	697	1,000
1985	96,639	2.4	158	16.4	10.8	14.2	6.3	21.6	1,461	2,000
1986	113,927	3.1	168	16.2	10.5	13.6	6.2	29.6	849	10,000
1987	104,288	2.2	178	16.5	8.7	13.3	6.1	22.7	1,014	10,000
1988	128,862	2.5	188	17.7	12.4	14.0	6.2	28.1	1,078	15,000
1989	116,989	2.1	193	20.6	13.4	15.4	6.2	28.0	1,214	20,000
1990	103,839	1.8	201	20.3	15.6	18.8	6.2	23.7	1,075	30,000
1991	79,497	1.9	236	24.1	19.7	18.2	8.7	27.0	1,086	40,000
1992	75,207	1.4	258	28.7	27.3	18.8	10.0	22.4	1,201	40,000
1993	71,787	2.6	216	38.6	46.0	25.0	12.1	44.5	766	45,000
1994	90,999	2.5	729	57.2	28.8	30.6	14.6	62.0	1,252	50,000
1995	96,994	3.0	855	53.2	1.6	25.3	22.0	68.7	1,056	60,000
1996	67,997	2.5	720	56.6	9.0	28.2	24.6	55.4	1,168	80,000
1997	55,634	4.0	954	62.7	11.2	28.3	30.0	88.0	3,322	120,000
1998	68,677	4.2	1236	61.9	6.6	29.5	32.3	87.0	8,547	150,000
1999	100,850	2.1	1152	72.9	5.7	22.4	33.1	50.0	8,751	300,000
2000	50,543	1.5	1251	78.1	10.0	22.3	35.7	38.0	937	300,000
2001	51,900	1.5	1052	78.6	5.8	19.7	36.4	35.3	1,110	350,000
2002	51,895	1.5	1358	77.1	2.0	18.5	37.1	35.0	927	350,000
2003	55,445	1.5	1482	76.1	9.8	16.4	37.8	35.4	7,980	400,000
2004	48,431	1.6	1363	77.3	11.6	12.5	43.5	38.1	1,050	450,000

2005	45,245	1.6	1300	72.4	10.3	12.9	49.8	40.2	3,540	500,000
2006	48,303	1.6	1300	69.4	9.0	13.6	56.4	39.4	1,418	700,000
2007	53,368	2.9	1200	67.3	9.8	13.3	58.0	78.2	3,775	1,000,000
2008	42,000	3.5	2500	69.2	13.1	14.0	60.0	98.0	1,035	1,500,000
2009	54,020	3.1	2614	77.4	12	14.8	62.0	98.1	3,476	2,000,000
2010	42,000	4.8	2800	79.2	9.3	14.6	65.0	150.5	1,137	2,000,000

KEY:

Y – Coffee Supply

Pc – International Coffee Prices

Pm – Price for maize

E – Exchange Rate

Inf– Inflation

R – Interest rates

Pi – Cost of inputs

Pt – Cost of handling coffee

W – Level of rainfall

Pl – Cost of land

APPENDIX II

Table AII: Log linear regression results

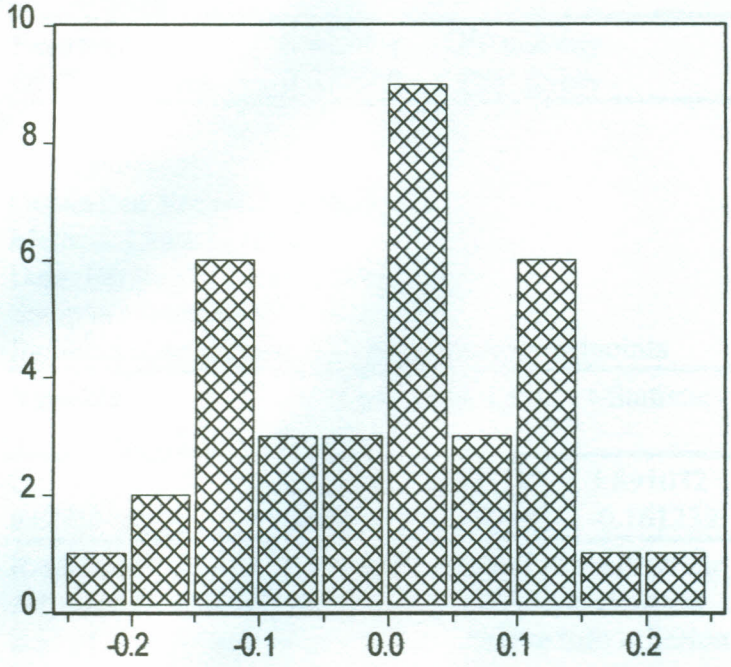
Dependent Variable: DLOG(Y)
Method: Least Squares
Date: 10/02/11 Time: 22:20
Sample(adjusted): 1976 2010
Included observations: 35 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.322560	0.184932	1.744212	0.0965
DLOG(Y(-1))	-0.266496	0.102671	-2.595624	0.0173
LOG(PC(-1))	0.032362	0.071159	0.454782	0.6542
DLOG(PI)	-0.307364	0.107577	-2.857149	0.0097
DLOG(PL)	-0.012961	0.073252	-0.176939	0.8613
DLOG(PT)	-0.353588	0.122722	-2.881222	0.0092
DLOG(PS(-1))	0.056760	0.090271	0.628782	0.5366
DLOG(ER)	0.387628	0.241577	1.604568	0.1243
DLOG(I)	0.025576	0.110327	0.231818	0.8190
LOG(INF(-1))	-0.022847	0.043848	-0.521039	0.6081
W	-0.159113	0.062594	-2.541983	0.0194
PE	-0.190553	0.088445	-2.154479	0.0436
T	-0.007230	0.004496	-1.607988	0.1235
Dummy79	-0.019544	0.154218	-0.126733	0.9004
Dummy84	0.209745	0.129403	1.620861	0.1207

R-squared	0.841016	Mean dependent var	-0.012674
Adjusted R-squared	0.729728	S.D. dependent var	0.227299
S.E. of regression	0.118168	Akaike info criterion	-1.135899
Sum squared resid	0.279272	Schwarz criterion	-0.469321
Log likelihood	34.87823	F-statistic	7.557071
Durbin-Watson stat	1.560093	Prob(F-statistic)	0.000032

APPENDIX III

Table AIII: Test for normality using Jarque-Berra statistic



Series: Residuals	
Sample 1976 2010	
Observations 35	
Mean	-4.44E-17
Median	0.009671
Maximum	0.232103
Minimum	-0.232536
Std. Dev.	0.116015
Skewness	-0.057055
Kurtosis	2.155536
Jarque-Bera	1.058956
Probability	0.588912

The histogramm is bell shaped and Jarque-Bera statistic is not significant therefore rejecting the null hypothesis of lack of normality.

APPENDIX IV

Table AIV: ARCH residual test for homoschedasticity

ARCH Test:

F-statistic	0.025996	Probability	0.872924
Obs*R-squared	0.027598	Probability	0.868057

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 08/26/11 Time: 13:46
Sample(adjusted): 1977 2010
Included observations: 34 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.013126	0.003373	3.891032	0.0005
RESID^2(-1)	-0.028316	0.175620	-0.161232	0.8729

R-squared	0.000812	Mean dependent var	0.012760
Adjusted R-squared	-0.030413	S.D. dependent var	0.014351
S.E. of regression	0.014567	Akaike info criterion	-5.563062
Sum squared resid	0.006791	Schwarz criterion	-5.473276
Log likelihood	96.57205	F-statistic	0.025996
Durbin-Watson stat	1.958512	Prob(F-statistic)	0.872924

APPENDIX V

Table AV: LM test for Autocorrelation

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.934516	Probability	0.409265
Obs*R-squared	2.991266	Probability	0.224107

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 08/26/11 Time: 13:48

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.062995	0.224860	-0.280154	0.7822
DLOG(Y(-1))	0.093811	0.162511	0.577262	0.5702
LOG(PC(-1))	-0.015337	0.087271	-0.175734	0.8623
DLOG(PI)	-0.026399	0.172873	-0.152709	0.8802
DLOG(PL)	0.057135	0.096985	0.589114	0.5624
DLOG(PT)	-0.002752	0.158818	-0.017331	0.9863
DLOG(PS(-1))	0.001466	0.119976	0.012218	0.9904
DLOG(ER(-1))	0.095272	0.349255	0.272787	0.7878
DLOG(I)	0.031073	0.136113	0.228289	0.8217
LOG(INF(-1))	0.007603	0.068895	0.110353	0.9132
W	0.025464	0.089363	0.284951	0.7786
PE	0.019050	0.109040	0.174703	0.8631
T	0.001074	0.005391	0.199296	0.8440
RESID(-1)	-0.399128	0.313329	-1.273829	0.2173
RESID(-2)	-0.195559	0.283404	-0.690035	0.4981

R-squared	0.085465	Mean dependent var	-4.76E-17
Adjusted R-squared	-0.554710	S.D. dependent var	0.116015
S.E. of regression	0.144657	Akaike info criterion	-0.731380
Sum squared resid	0.418511	Schwarz criterion	-0.064802
Log likelihood	27.79914	F-statistic	0.133502
Durbin-Watson stat	1.876981	Prob(F-statistic)	0.999810

APPENDIX VI

Table AVI: Johansen Cointegration Test

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.999989	772.2959	212.67??	226.40??	None **
0.900311	362.0344	212.67??	226.40??	At most 1 **
0.871633	279.0293	212.67	226.40	At most 2 **
0.765429	205.1264	175.77	181.44	At most 3 **
0.718016	152.9264	141.20	152.32	At most 4 **
0.663366	107.3538	109.99	119.80	At most 5
0.497364	68.15846	82.49	90.45	At most 6
0.415807	43.39444	59.46	66.52	At most 7
0.285505	24.04358	39.89	45.58	At most 8
0.172681	11.94111	24.31	29.75	At most 9
0.131892	5.116784	12.53	16.31	At most 10
0.000694	0.024977	3.84	6.51	At most 11

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
?? denotes critical values derived assuming 10 endogenous series

APPENDIX VIII

Table AVIII Residual

Actual	Fitted	Residual	Residual Plot
0.12022	0.24419	-0.12397	| * | . |
0.27677	0.20319	0.07358	| . | * . |
-0.17853	-0.31503	0.13650	| . | .* |
-0.11081	-0.11081	7.3E-17	| . * . |
0.22203	0.10656	0.11547	| . | * |
0.08164	0.13006	-0.04842	| . * | . |
-0.12758	-0.06959	-0.05799	| . * | . |
-0.01709	-0.02867	0.01158	| . |* . |
0.41142	0.41142	-5.6E-17	| . * . |
-0.28837	-0.40618	0.11781	| . | * |
0.16458	0.17696	-0.01238	| . *| . |
-0.08840	0.00120	-0.08960	| .* | . |
0.21159	0.10619	0.10540	| . | *. |
-0.09666	-0.07637	-0.02029	| . *| . |
-0.11924	-0.02175	-0.09749	| .* | . |
-0.26712	-0.17989	-0.08723	| . * | . |
-0.05547	-0.03250	-0.02298	| . *| . |
-0.04654	-0.19941	0.15287	| . | . * |
0.23715	0.22625	0.01089	| . |* . |
0.06380	0.15682	-0.09302	| .* | . |
-0.35519	-0.26021	-0.09497	| .* | . |
-0.20067	-0.12860	-0.07207	| . * | . |
0.21062	0.22332	-0.01270	| . *| . |
0.38422	0.40934	-0.02512	| . *| . |
-0.69081	-0.45377	-0.23704	|* . | . |
0.02649	0.12844	-0.10195	| .* | . |
-9.6E-05	-0.09678	0.09668	| . | *. |
0.06617	-0.03923	0.10539	| . | *. |
-0.13525	-0.22063	0.08537	| . | * . |
-0.06805	-0.14519	0.07714	| . | * . |
0.06540	0.01374	0.05166	| . | * . |
0.09972	0.03210	0.06761	| . | * . |
-0.23954	-0.19035	-0.04919	| . * | . |
0.25168	0.15618	0.09550	| . | *. |
-0.25168	-0.19461	-0.05707	| . * | . |

APPENDIX IX

Table AIX (1) short run elasticity of the integrating variables.

Dependent Variable: Y
Method: Least Squares
Date: 10/04/11 Time: 09:54
Sample: 1974 2010
Included observations: 37

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.835660	0.123547	39.14040	0.0000
PI	-0.338801	0.101472	-3.338861	0.0023
PT	-0.201388	0.178024	-1.131242	0.2669
PC	0.144993	0.069794	2.077443	0.0464
INF	-0.041292	0.045009	-0.917421	0.3662
I	0.243258	0.071331	3.410256	0.0019
ER	0.280928	0.154717	1.815746	0.0794

R-squared	0.819565	Mean dependent var	4.867521
Adjusted R-squared	0.783479	S.D. dependent var	0.141693
S.E. of regression	0.065932	Akaike info criterion	-2.431715
Sum squared resid	0.130412	Schwarz criterion	-2.126947
Log likelihood	51.98674	F-statistic	22.71088
Durbin-Watson stat	1.307006	Prob(F-statistic)	0.000000

Table AIX (2) Long run elasticity (ECM)

Dependent Variable: D(Y)
Method: Least Squares
Date: 10/04/11 Time: 10:02
Sample(adjusted): 1975 2010
Included observations: 36 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PI)	-0.469473	0.097948	-4.793072	0.0000
D(PT)	-0.333543	0.121509	-2.745008	0.0103
D(PC)	-0.009921	0.073794	-0.134447	0.8940
D(INF)	-0.008504	0.028931	-0.293958	0.7709
D(I)	0.168089	0.095313	1.763542	0.0883
D(ER)	0.519814	0.172774	3.008644	0.0054
RESIDUAL(-1)	-0.621289	0.157068	-3.955551	0.0005

R-squared	0.781391	Mean dependent var	-0.006505
Adjusted R-squared	0.736161	S.D. dependent var	0.097479
S.E. of regression	0.050070	Akaike info criterion	-2.978104
Sum squared resid	0.072705	Schwarz criterion	-2.670198
Log likelihood	60.60588	F-statistic	17.27612
Durbin-Watson stat	1.862108	Prob(F-statistic)	0.000000