AGRICULTURAL SUPPLY RESPONSE: A LOOK AT THE DETERMINANTS OF MAIZE PRODUCTION IN KENYA (1963-2006)

BY

GRACE A. OMODHO

A research paper submitted to the School of Economics, University of Nairobi, in partial fulfillment of the Degree of Master of Arts (Economics)

August 2008

This research paper is my original work and has not been presented for a degree in another university.

Grace A. Omodho

This research paper has been submitted for examination with our approval as university supervisors.

Dr. D. M. Kulundu

Mr. L. M. Awiti

Table of Contents

DEDICATION

This paper is dedicated to my parents, the late Mr. S. W. Omolo and Mrs. F. Omolo for their love and immense belief in my abilities. Every aspect of my life is shaped by the valuable lessons I learnt from you.

ACKNOWLEDGEMENT

My greatest thankfulness is to the Almighty God for the gift of life and the privilege He has given me to pursue these studies. His enduring love for me gave me the spirit and strength to fight on even during the most difficult of times.

In writing this paper, I am deeply indebted to many people, without whom the work could not have been successfully undertaken. My sincere gratitude goes to my supervisors, Dr. D.M. Kulundu and Mr. L. M. Awiti for their patience, dedicated insights and direction that steered and shaped this piece of work. Without their encouragement and guidance, I would not have been able to complete this work.

I express my profound appreciation to Drs. Wilfred Nyangena and Moses Sichei for extremely useful comments and suggestions at the initial and critical stages of the work. A special thank you also goes to all the staff members of the School of Economics for their help, encouragement and support throughout my studies.

To my classmates, it was a wonderful experience being in the same class with you. The class discussions were useful and you will forever remain a significant part of my life.

Last but not least, special thanks to my family – my husband David and my children Nicole and Laura - for their patience, understanding and moral support that went a long way in nudging me to soldier on despite the challenging moments.

May God bless you all!

ABSTRACT

Over the last few years, the annual rate of food production has fallen below the annual rate of population growth. This has led to food shortages, sometimes culminating in famine situations. In order to assuage this situation, there is need to explore ways of increasing food production. Maize is one of Kenya's most important staple food crops and is grown by both large and small scale farmers. The importance of maize cannot be overestimated. Maize is so important that in Kenya, shortage of maize is synonymous with famine. Due to the fact that maize is the staple food of most Kenyans, its production has gained a lot of emphasis since failure to produce enough maize would mean that food security is threatened.

The study set out to identify and analyze the determinants of maize production in Kenya in the period 1963 – 2006. The study looked at both price and non-price factors influencing maize production including prior period yield, exchange rate, macroeconomic environment, credit to the agricultural sector, political environment, weather and seed quality. An error correction model was used to analyze the long-run and short-run effects of various factors determining maize production. The study found that acreage under production, producer prices, GDP growth rate, yield, seed quality and weather were all significant determinants of maize production. The study also found that Kenyan maize farmers do not respond to changes in civil unrest and that liberalization of the maize industry is likely to have had a positive impact on maize production.

The study suggests that producer prices alone are inadequate to influence maize production and recommends a compatible and integrated policy regarding the provision of input subsidies, improved seed quality and enhanced support for the agricultural sector to improve production. An improvement in the institutional framework and policy environment is necessary to support and sustain maize production.

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE - INTRODUCTION

Kenya's economy largely depends on the agricultural sector, which accounted for 5.4% of the GDP growth in 2006 (Economic Survey, 2007). About 75% of Kenyans owe their livelihood to agriculture. Other than agro production, the sector boasts a comparatively wide range of manufacturing industries, with food processing being the largest single activity. About 66% of the manufacturing sector is agro-based, owing to the country's agricultural economic foundation. The agro-grain processing sub sector is one of the leading and well-established industries and it includes major cereal foods such as maize, wheat, rice, sorghum, millet and barley among others.

Maize is one of Kenya's most important staple food crops and is grown by both large and small scale farmers. The importance of maize cannot be overestimated. Maize is so important that in Kenya, shortage of maize is synonymous with famine. Although maize is a crucial staple food crop, the average yield per hectare in Africa is the lowest in the world. According to the Food and Agricultural Organization (FAO), the world-wide average maize yield per hectare is about 4 metric tons, but in Africa it is 1.7 metric tons, less than half the global average.

In Kenya, the annual average production of maize is 2.7 million tons, which is lower than the estimated consumption of 3.1 million metric tons (Nyoro et al., 2004). The area under maize cultivation is approximately 1.6 million hectares. Maximum crop production in a good season is about 34 million bags and drops to 18 million bags during drought years. The small-scale farmers account for about 75% of the total maize production in Kenya, with large-scale farmers producing the remaining 25%.

Due to the fact that maize is the staple food of most Kenyans, its production has gained a lot of emphasis since failure to produce enough maize would mean that food security is threatened. Maize production also provides the bulk of incomes for the farmers. Large fluctuations in maize production also generate large price fluctuations.

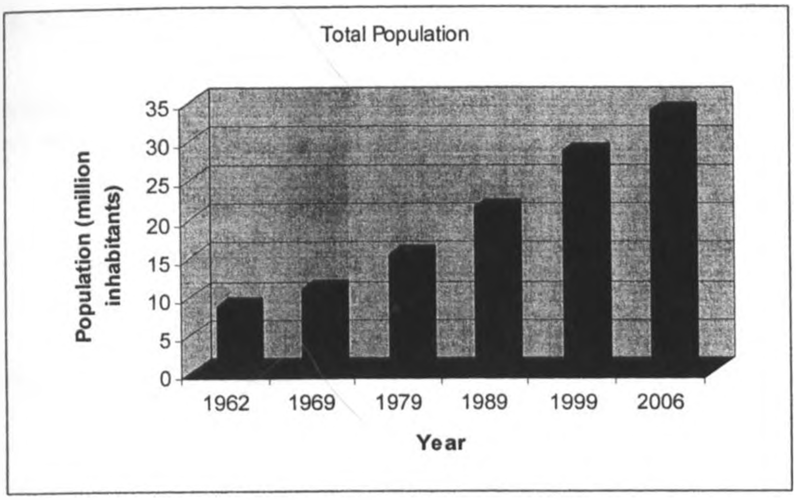
The National Cereals and Produce Board (NCPB) is mandated to regulate the maize industry in all aspects by maintaining the highest possible standard of grain quality hygiene, ensuring quality control and security of stocks. The Board facilitates famine relief food distribution, farmer education, school feeding programmes and promotes use of traditional crops so as to ease pressure on conventional grains. The Board is involved in import and export of cereals to meet local demand or widen market outlets during times of shortage or surplus production respectively. The Board also disseminates information relating to maize and advises the Government on all policy matters regarding the industry through the Ministry of Agriculture. During bumper harvests, Kenya exports its maize to Tanzania, Uganda, Rwanda, DRC, Sudan and Ethiopia among other countries, while importing from USA, South Africa, and Zambia when faced with deficits.

1.1 OVERVIEW OF AGRICULTURE IN KENYA

Agriculture remains the most important economic activity in Kenya. Domestic agricultural production is the centre of the country's economy because of the proportion of people who depend on agriculture for income and employment. About 80% of the work force engages in agriculture or food processing. Farming in Kenya is typically carried out by small producers who usually cultivate no more than two hectares (about five acres) using limited technology. These small farms, operated by about three million farming families, account for 75% of total production. Although there are still important European-owned coffee, tea, and sisal plantations, an increasing number of peasant farmers grow cash crops.

Kenya's agricultural sector like the rest of the economy has performed poorly over the last decade. This poor performance is mirrored in the production of key food commodities and export products thereby adversely affecting food security, reducing employment opportunities and increasing overall poverty in rural areas. The decline in food production has particularly taken place against a background of growing demand for food, largely driven by an increasing population. Figure 1 below shows the population growth trends for the period 1962-2006[1].

Figure 1: Kenya's Population (1962-2006)



Source: Central Bureau of Statistics, Kenya

1.2 MAIZE PRODUCTION IN KENYA

Maize production peaked during the mid-to-late 1980s, and stagnated between 1995 and 2000. From 1990, maize production varied between 24 and 33 million bags (2.1 to 3.0 million tons) per year, and averaged 2.4 million tons between 1990 and 2003. Production has been on an upward trend from the 2000 onwards.

Although the area under cultivation had been on the upward trend in the period up to 2000, production had, however, been on a downward trend. Nyoro et al., (2004) attributed this decline to declining yields which declined from 2.07 tons per hectare in 1982/83 to 1.56 tons per hectare in the 2002/03 season. However, recent statistics indicate that yield has been on an upward trend since the year 2000 (1.44 tons per hectare to 1.93 in 2004).

[1] Figures for 2006 are projections.

During the years, maize production in Kenya has not kept pace with consumption. Consumption has mostly exceeded production mainly due to population growth. Table 1 below compares the population growth to the growth in maize production from 1962 - 2006[2].

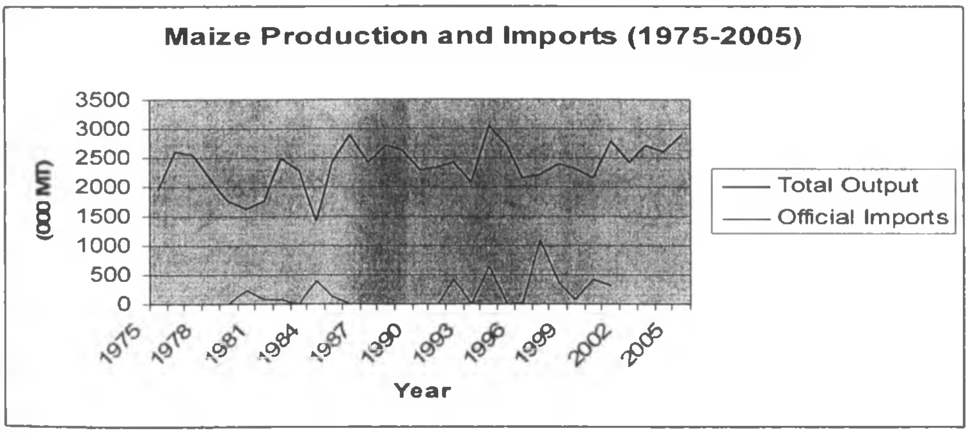
Table 1: Growth in population versus Growth in Maize production

	Population (Million inhabitants)	% growth	Maize Production (Million tons)	% growth	Difference
1962	8.64		1.20		
1969	10.94	26.71%	1.72	43.33%	16.62%
1979	15.33	40.06%	1.76	2.03%	-38.03%
1989	21.44	39.91%	2.63	49.91%	10.00%
1999	28.69	33.78%	2.32	-11.74%	-45.52%
2006	33.95	18.34%	3.25	39.83%	21.49%

Source: Central Bureau of Statistics, Kenya

To bridge this increasing gap between maize supply and demand, Kenya has been importing maize formally and informally across the border from Uganda and Tanzania in addition to large offshore imports from as far as South Africa, Malawi, USA and other Southern America countries like Brazil and Argentina (Nyoro et al., 2004). The imported maize has been cheaper than that locally produced. To protect the domestic producers, the government has applied tariffs thus raising the price of maize. While this has been beneficial to producers, the high prices are a disadvantage to the consumers.

Figure 2: Maize production and Imports (1975-2005)



Source: FAO statistics

[2] Population figures for 2006 are projections.

The use of substitutes has also been limited due to the fact that production of possible substitutes has been low. Table 2 below shows the production of some substitute crops in the period 2000-2005.

Table 2: Production of Substitute Crops (2000-2005)

Year	Wheat (000 tons)	Sorghum (000 tons)	Millet (000 tons)
2000	204.23	81.54	44.62
2001	257	116.61	44.62
2002	307.22	115.58	72.20
2003	378.67	127.22	63.62
2004	379.43	69.51	50.47
2005	368.88	149.66	53.10

Source: FAO Statistics, 2007

Kenya for a long time pursued the goal of attaining self-sufficiency in production of key food commodities including maize. The policy of food self-sufficiency implies that there is sufficient food production of food and stocks to meet domestic demand and if possible have surplus for exports. However, Kenya now pursues a policy of food self-reliance which implies that the country's requirements are met through a combination of production, stocks and imports. This is because Kenya's maize production is not able to meet the demands of its growing population.

1.3 POLICIES ON THE MAIZE SUB-SECTOR

Domestic policies on maize production and trade have been the preoccupation of government planning throughout most of Kenya's history. Policies evolved from an era of statutory market controls initiated in the 1930s, through the reforms era of the 1980s. This was followed by the Structural Adjustment Programmes (SAPs) that were characterized by a reduction in trade barriers and abolition of administration controls resulting in full market liberalization in 1995. These reforms were envisaged to improve producer prices as a means of stimulating production and growth (Karanja et al., 2003)

Between 1964 and 1980, the government emphasized intervention in nearly all aspects of agricultural production and marketing. The responsibility of controlling the policies was vested in the Ministry of Agriculture but implementation of the policies was undertaken by several public institutions, mainly established statutory boards. By 1981, however, the government had made a shift away from excessive control of agricultural production and marketing towards provision of an enabling environment for greater participation by the private sector.

Post Independence Period (1963-1975)

Prior to independence, agricultural extension policy had focused on European farmers. Upon attainment of independence in 1963, the government based its agricultural policies on the Sessional Paper No. 10 which emphasized political equity, social justice, and human dignity. During this period, the government devoted about 10 per cent of its annual budget to agricultural research (Nyangito, 1998). This resulted in major breakthroughs in the discovery of high-yielding maize varieties. The use of purchased inputs was promoted through farmers' cooperative societies and crop marketing boards and authorities in two ways: licensing of distributors and input price subsidization. Credit was also made available through the Agricultural Finance Cooperation.

Pricing and marketing policies in the colonial era had emphasized direct government control for the major food crops including maize. In 1935, the government enacted the Native Produce Ordinance in order to create a statutory monopoly geared towards the protection of European maize farmers form competition by African producers. The Maize Control Board (MCB) was created to be the sole purchaser of maize and other grains at a fixed price and the provider of a minimum guaranteed return per acre for colonial settlers. Upon attainment of independence, the government continued to control maize pricing by setting prices in advance each year to encourage farmers to increase maize production. Marketing was also controlled through the Maize Marketing and Produce Board

(MMPB), later renamed the National Cereals and Produce Board (NCPB). The Board performed several functions including, buying all maize offered at the set producer price and selling it to millers/agents at the set selling price, controlling foreign trade in maize, controlling the movement and distribution of maize in the country

The Era of Controls (1975 -1982)

The period after 1970 witnessed declining agricultural production due to inefficiency in marketing, limited land expansion of small holder farming, limited development and use of new technologies, restriction on private trade and processing of commodities, and deteriorating infrastructure. In 1976, a special programme aimed at improvement of small scale farms was introduced – the Integrated Agricultural Development Programme (IADP). The programme, funded by donors to support extension services, supply input and credit and strengthen the cooperative movement, was highly successful. But it had to be discontinued in 1979 due to the high financial demands and reduced funding from donors. A new extension system was introduced in 1982 – the Train and Visit system. The system entailed regular visits to farmers, training of front-line extension workers and transfer of technical knowledge to farmers and feed back of the framers' problems through farm visits by the front-line extension staff.

Government policy on inputs had operated under free market conditions during the colonial era. But after independence, the Kenya Farmers Association (KFA) and a few private companies were responsible for all imports. Prices were set in line with a joint proposal that the importers submitted to the government for review. This resulted in an oligopoly situation where importation and distribution were controlled and a situation in which the importers colluded in the setting of prices of inputs (fertilizers in particular). The government eventually legislated against oligopoly with the subsequent introduction of wholesale and retail margins for the distribution of fertilizers. The government equally controlled the fertilizer market by imposing import quotas, setting prices, and establishing controls on distribution and marketing margins.

The First Phase of Reforms (1982 – 1992)

From 1980, the government's focus shifted from controls towards a liberal state ideology emphasizing reduced state intervention in the economy and free market operations. Policy reforms emphasized a liberalization of the grain market and a removal of price controls for all agricultural commodities. However, implementation of these reforms was sluggish and was characterized by some degree of resistance. For example, although the government had emphasized restructuring of the National Cereals and Produce Board to confine its role to being the buyer and seller of last resort, the government continued to exert some form of central regulation for food security reasons. Nevertheless, the government, in 1989, eliminated price controls on fertilizers.

The Second Phase of Reforms and Liberalization (Post 1993)

Although there had been a modest growth in agricultural production in the period 1980-1990, this was followed by a steady decline in the period after 1990. The reasons for the decline were: poor implementation of policies, bad weather, deteriorating terms of trade between agricultural exports and imports, rapid population growth and shortage of land in the high and medium-potential areas of agricultural production, and a decline in public investment in agriculture in real terms (Nyangito, 1988).

The period after 1993 was characterized by a focus on decontrol and removal of obstacles in the marketing and distribution system. Fertilizer import licensing was made automatic in 1993. Foreign exchange controls and import licensing were eliminated in 1994 leading to the full liberalization of the fertilizer market. Today, the fertilizer market is dominated by the private sector. The government, however, receives fertilizer as aid or as balance of payments support which it in turn sells to private traders. The government also intervenes in the inputs market through import duties and taxes from which fertilizers and heavy agricultural machinery are exempt.

Towards the end of 1995, the government liberalized the maize market and removed all restrictions on maize movements and trade. This also resulted in the discontinuation of the Kenya Maize Market Development Programme (KMDP) whose aim had been to provide trading information and developing roads and market infrastructure. As such, availability of information to market participants and access to markets remains a problem. The problem is a disadvantage to producers in remote areas who cannot sell their maize profitably, a failure that is a disincentive to increased production (Nyangito, 1998).

In terms of maize research, the Kenya Agricultural Research Institute (KARI), working closely with the Kenya Seed Company (KSC), had previously monopolized maize breeding programmes. The former monopolized the multiplication of new maize varieties and the production and distribution of improved maize. With the liberalization of the seed sub-sector in 1996, new seed multiplication firms entered the market.

1.4 STATEMENT OF THE PROBLEM

Over the last few years, the annual rate of food production has fallen below the annual rate of population growth. This has led to food shortages, sometimes culminating in famine situations. In order to assuage this situation, there is need to explore ways of increasing food production. Increased food production could be achieved either by increasing the acreage cultivated or by intensifying production on the area already under cultivation. Because the area under cultivation is limited in Kenya, the most viable way to increase food production is to intensify production.

Owing to the large proportion of the Kenyan population earning a living out of agriculture, increased poverty can be attributed to declining agricultural production. A decline in agricultural production can be directly linked to food shortages, underemployment, low incomes from crops and poor nutritional status which further reduces labour productivity. There is therefore need to ensure that agricultural production is intensified in order to avert these problems. A study on the factors that influence production is important in this regard.

In recognition of the importance of maize production in Kenya's agricultural sector, several studies have been conducted on the maize sub-sector. Some studies have looked at the need to raise productivity (Nyoro et al., 2004) and others have looked at the effects of climate change on maize production (Mati, 2000). Others have also identified increasing competitiveness through reduced production costs (Nyoro et al., 2001), the effects of government marketing policies (Jayne et al., 2005), technical efficiency (Kibaara, 2005) and infrastructure constraints (World Bank, 1994) as factors that affect maize production in Kenya. The study identified several non-price factors constituting significant constraints to the supply responsiveness in SSA economies including inadequate infrastructure, poorly developed markets, rudimentary industrial sectors and severe institutional and managerial weaknesses in the public and private sectors.

Despite the numerous studies that have been carried out on the maize sector, maize production continues to fall below the desired levels in Kenya. This is an indication that there is still need for more comprehensive studies encompassing additional determinants of maize production. The study of agricultural production from a supply response perspective is important because growth in agricultural production is necessary not only to increase food availability and raise nutrition levels of the population; it is essential to the development process. Indeed it is accepted that a prerequisite for rapid economic growth is the channeling of agricultural surplus (production in excess of own consumption) to the non-farm sector (Coleman and Young, 1989).

The need to study agricultural supply response in the Kenyan economy is rooted in the importance of agriculture already outline above. A study specific to maize is necessary not only because of the importance of maize to the Kenyan people but also because few supply response studies have been carried out that are specific to this sub-sector in the recent past. The studies on agricultural supply response carried out in Kenya have mainly looked at cash crops. Kabubo (1991) studied the factors influencing the supply of wheat in the period 1970-1989 while Ongile (1996) studied agricultural supply response in the tea sector for the period 1986-1996. Other studies looked at supply response for coffee (Maitha, 1969) and a mixture of dairy and maize production in Nandi District

(Metson, 1978). Munyi (1999) also undertook a district level maize supply response study in Kenya. Odhiambo et. al (2004) studied the sources and determinants of agricultural growth in the period 1965-2001 but the study was not specific to maize. Another study that was not specific to the maize sector but dwelt on the positive responses of agriculture to price changes was that by the World Bank (1994). There is therefore a gap in the supply response literature as concerns the maize sector in Kenya.

Furthermore, some of these studies, while using time series data sets did not perform certain important tests that are necessary to validate the outcome of the studies. The study by Kabubo (1991) and Ongile (1996) for example, did not carry out any stationarity tests which are important if one is to avoid spurious results. Additionally, these studies are now well over ten years old and there have been recent developments that have occurred in the maize sector (e.g. liberalization in 1996). These developments have had various impacts on maize supply response that would need to be studied in further detail. Finally, previous studies have left out some important factors that influence supply response such as the exchange rate, macroeconomic environment and the political environment. This study hopes to be more comprehensive by studying both price and non-price factors influencing maize production including prices and prior period yield in addition to the macroeconomic environment, exchange rate, political environment, credit to the agricultural sector, weather and seed quality. In using time series data this study will also carry out the necessary normality, stationarity and cointegration tests.

1.5 OBJECTIVES OF THE STUDY

The overall objective of this study is to analyze the determinants of maize production in Kenya. The specific objectives of the study are:

(i) To identify the determinants of maize production in Kenya;

(ii) To analyze the relative significance of the determinants of maize production;

(iii) To make recommendations on how Kenya can improve maize production.

1.6 *JUSTIFICATION OF THE STUDY*

The need for increased production (to ensure sustained food security and to sustain rural incomes) suggests that there is justification for further studies on the determinants of maize production. Maize in Kenya cannot be easily substituted for other grains (e.g. wheat, rice, millet and sorghum) whose production remains far much lower than that of maize, but also because maize has a cultural value as the most important staple food. Maize is an important economic activity that is also intertwined in the country's history.

While importation of maize may be cheaper and may thus have better welfare implications for the consumer, it may spell doom to the producers the majority of whom are small scale farmers. Increased importation at the expense of production would lead to a drop in income for the producers especially the small scale farmers, further aggravating their poverty levels. As such, maize production is an important economic activity for the rural farmer which also impact on poverty levels.

The present study aims to add on to existing literature on maize supply response in Kenya. It is hoped that the findings of the study will help in formulating appropriate policies and programmes to further increase maize production. The results of the study could also be adapted to other economies facing similar problems in maize production as in Kenya.

CHAPTER TWO - LITERATURE REVIEW

2.1 *THEORETICAL LITERATURE*

The principal activity of any firm is to turn inputs into outputs. The relationship between inputs and outputs is formalized by a production function of the form

$$q = f(K, L, M \ldots.) \qquad (2.1)$$

where q represents the firm's output of a particular good during a period, K represents capital usage during the period, L represents hours of labour input, M represents raw materials used, and the notation indicates the possibility of other variables affecting the production process. Equation 2.1 is assumed to provide, for any conceivable set of inputs, how best to combine those inputs to get output (Nicholson, 2002).

Methods of production improve over time, and it is important to be able to capture these improvements in the production function concept. A simplified view of such progress is indicated by shifts in the production function where the same level of output can be produced with fewer inputs or increased output can be achieved with the same level of inputs.

Suppose we let

$$q = A(t) f(K, L) \qquad (2.2)$$

be the production function for some good. The term A (t) in the function represents all the influences that go into determining q other than K and L. Changes in A over time represent technical progress. For this reason, A is shown as a function of time. Assume $dA/dt>0$, particular levels of input of labor and capital become more productive over time.

But the elasticity of output with respect to capital input is:

$$\partial f / \partial K \bullet (K / f(K,L) = \partial q / \partial K \bullet K / q = e_{qK} \qquad (2.3)$$

And the elasticity of output with respect to labor input is:

$$\partial f / \partial L \bullet (L / f(K, L) = \partial q / \partial L \bullet L / q = e_{qL} \quad (2.4)$$

Therefore, our growth equation finally becomes

$$Gq = GA + e_{qK} G_K + e_{qL} G_L \quad (2.5)$$

This shows that the rate of growth in output can be broken down into the sum of two components: growth attributed to changes in inputs (K and L) and other 'residual' growth (that is, changes in A). For our study, we adopt this approach to look at those factors that can be classified into A that will influence the growth in output of maize.

Economic theory suggest that the market supply of a product will depend on the price of the commodity, the prices of other commodities which could be produced and the prices of inputs into the production process. The relationship can be expressed in the form of a supply function:

$$Qi = f(Pi, P_l, P_1, ...Pn) \quad (2.6)$$

Where Q*i* denotes the market supply of a product *i*, which has P*i* as its current market price. The prices of alternative products, *j* and *k* are given as P*j* and P*k*, and the set of (n) input prices are specified as $p_1, \ldots, p_n$. Assuming that the prices of other products and inputs are held constant, we can trace out the relationship between the supply of commodity *i* and its own price, i.e. the supply curve or supply schedule.

The cobweb model is a dynamic model which has received particular attention by agricultural economists. The cobweb model provides an explanation for certain cyclical behaviour and has been used as the basis of theoretical and empirical analysis of several product markets. The dynamics in the model derive from the particular specification of the supply relations. The model assumes that production plans are based on current price and that there is a one period time lag in production response. Hence the expected price (P^*_t) for output sold in period t is equal to the actual price in the previous period (i.e. $P^*_t = P_{t-1}$).

When household consumption behavior is not independent of its production, the decision making process is said to be recursive and is best analyzed using household production functions. The household sets its production and consumption decisions so as to maximize utility subject to a budget and time constraint. The first order conditions of the Lagrangean Function are the standard conditions from consumer demand theory and the theory of the firm. Their solutions yield standard commodity demands as a function of prices and income and output supply.

2.2 *EMPIRICAL LITERATURE*

Studies from other parts of the World

In a study conducted in Zitacuaro municipality in Michoacan, Mexico, Heath (1987) explored the rationale for producing maize from the viewpoint of the peasant enterprise. Heath looked at the factors that influence yield, cost of production and price, considering how these combine to determine the rate of return of maize production and the volume of grain sold by the enterprise. The study was motivated by the fact that domestic supply of maize (which was considered a very important staple food) had not expanded sufficiently to meet the rise in demand. Rapid population growth had led to a sharp fall in the per capita availability of domestically produced maize leading to progressively increased maize imports to the point where imports represented one-fifth of domestic production. Using a survey of 22 households, the study focused on the employment of land and labor resources, the cost of maize production and the way in which maize was distributed in the 1984-85 maize cycle. A partial survey of the marketing system was also conducted to identify the volume of maize that different communities in the municipality delivered to the granaries. By ranking the 22 enterprises by order of the net income they derived form maize production in the 1984-85 maize cycle, the study divided them into two groups on high and low returns to maize production. The yield of 'high return' enterprises was found to be lower than might have been expected and only marginally superior to the national average. The difference in mean costs of production between the high and low return groups was not large enough to be statistically significant. The price received by maize producers for their product did not vary significantly between the two groups. It was concluded that in Zitacuaro, therefore, the return to maize production was not a function of marketing channel (a highly atypical state of affairs). The study results indicated that maize was unconditionally a loss-making activity for the low return group with the mean cost per kilo of maize produced being more than two and one half times higher than the guaranteed price. With respect to distribution, the study found three main differences between the high return and the low return group: the level of per capita consumption by household members; the size of the marketed surplus; and the selection of marketing channel.

The study concluded that the low yield-high cost characteristics of maize production in Zitacuaro were representative of conditions faced by most maize producers in Mexico. In confronting this problem, Mexican policy makers identified the need to boost the supply of domestically produced grain in order to increase long-term food security, to save foreign exchange spent on maize imports and to reduce pressure on wage rates. A major weakness of the study was the small sample size and the fact that the study only covered one maize cycle. This could have compromised the outcome of the study.

Studies from Other African Countries

Studies from other African countries present interesting results. Mazivila (2002) estimated price response coefficients for maize in Mozambique using ordinary least squares and time series analysis. The study used a Nerlovian adjustment type model to estimate maize supply response to price policy for the period 1975-2000. Although the study found that 62% of the variations in the area harvested was explained by the changes in the dependent variables (lagged price, area and yield and actual rainfall), the study found that Mozambican farmers did not respond to price incentives. Shorter policy lags and rainfall were also found not to be significant for the study period. The study however found that supply of maize was sensitive to agro-climate and the traditional cropping patterns of the Mozambican farmers. The study did not consider some important variables such as access to credit and infrastructural development in the study.

Simatele (2006) examined the impact of selected structural adjustment policies on food production (maize, millet, sorghum, groundnuts, sweet potatoes and cassava) in Zambia. Using an actual-versus-target approach where performance targets are set for the economy and the impact of the programme is judged on the basis of how well it performs against the preset targets, the study applied a Heckman selection model to estimate price elasticities and used these to simulate effects of policy on the production of several foods crops in Zambia. Although the study noted that the continual increase in the exchange rate may have had a negative effect on maize production, simulated policy effects found that freeing the exchange rate alone would lead to a meager 5.8% increase in maize output. Own price elasticities were found to be positive and significant for maize and groundnuts and negative for the rest of the crops. The results also showed sluggish response in maize output to non price factors. The conclusion was that maize being a major staple food was more dependent on structural variables such as information, distance to market and credit than other crops. One weakness that was noted in the study was the fact that the study used a four-year panel of post-harvest data. Perhaps better results would have been achieved if the study period was longer.

Studies from Kenya

In a recent study, Kingori (2005) looked at the impact of agricultural trade support in developed countries on maize prizes in Kenya by analyzing how prices are transmitted from OECD countries to the domestic market in Kenya. Vector Auto regression (VAR) models were used in the analysis of price transmission. A simulation of the price of maize imports was estimated to represent the cost of maize imports if market price support and payment of output to producers were eliminated in developed countries. The study found that domestic maize prices in Kenya are affected by maize imports from OECD countries. There was cointegration between domestic and imported maize prices which implies that these prices co-move in the long run and therefore there was price transmission from developed countries to the domestic maize market. The decision to study the effects of prices from OECD countries was based on the fact that 35% of total maize imports over the period 1995-2004 were from developed countries. In our opinion this was not a significant proportion of the imports and hence the analysis could have benefited from a comparison of effects of prices from other regions from which the country imports maize.

Using a Vector Autoregressive (VAR) model, Jayne *et al,* (2005) estimated the effects of government policy on wholesale maize prices and their volatility in Kenya. The authors estimated a counterfactual set of maize prices that would have occurred over the 1990 – 2004 period had the NCPB not existed and had tariffs been abolished. The study found that NCPB's operations raise wholesale market prices while the import tariff exerts only modest effects on open market maize price levels. While the VAR approach helps to overcome the Lucas critique by endogenizing policy variables, it is not as informative as the behavioral supply-demand relationships used in simulation models.

A comparison of the competitiveness of Kenyan and Ugandan Maize Production was carried out by Nyoro et al., (2004). The study sought to analyze actual farmer behavior to understand why some were able to achieve high levels of productivity while others in the same area were achieving much lower productivity. The study examined the range of maize production costs achieved by small-scale and large-scale farmers in several maize producitng zones in Kenya, and compared them to maize costs of production in eastern Uganda. Production cost data used in the study were based on a single-visit survey of 581 rural Kenyan and Ugandan households in April-May 2003. The data collected included land size holding, area planted to maize and intercrop (owned and rented), crop output and prices, quantity of family labor and quantity and cost of hired labor, quantity and prices of material inputs (seeds, chemicals, fertilizer), and quantity and costs of tractor and draught inputs. All maize fields under the survey were classified into different production technology categories (PTC) based on various criteria and two types of seed varieties used namely, hybrid and open pollinated varieties (OPV). Production costs per acre were determined based on information on family and hired labor usage for all reported labor activities, land rental rates, land preparation costs, cash input costs such as fertilizer and purchased seed.

The study results showed that land preparation costs varied across PTC but differences were less pronounced for the intercrop system. Labor costs also showed variation across categories. Fertilizer costs were, as expected, high in areas with higher fertilizer intensity while seed costs were relatively low in Uganda. Production costs were found to differ greatly across production technology categories. Overall, all costs except land preparation were found to be generally higher in Kenyan production systems than in Uganda with labor and land preparation costs being the main source of the difference between high and low cost producers. The study concluded that poor crop husbandry, high cost of farm inputs and machinery, seed quality and a weak extension system were the main contributors of the high cost of Kenyan maize production. As such, the authors recommended more concerted efforts into maize technology generation, diffusion and quality control policies if Kenya wished to compete with neighboring countries. Although the study aimed to compare costs of production in Kenya and Uganda, the study was heavily skewed in favor of Kenya. Of the 581 households surveyed, 77% were Kenyan. A more balanced outcome may have been achieved had the study balanced the survey across households in the two countries.

Nyangito (1997) reviewed and evaluated the impact of the policies used over the years in a bid to identify the main policy concerns in the maize sub-sector that need to be addressed. The identification, the study noted, would help the stakeholders overcome the constraints in the production and the marketing of maize. The study looked at policies relating to research and extension, inputs, pricing and marketing. With regard to research policy, the study identified the need to develop high yielding varieties for the medium-potential growing areas, the removal of Kenya Seed Company monopoly to the KARI outputs, and the setting up of an impartial institution to inspect the production and the marketing of maize seed in an effort to ensure that investments in maize breeding by private companies can be well protected. On extension services, the study highlighted the need to focus on extension policies which would lead to effective dissemination of improved technologies from research centers to farmers' fields. The main policy issues surrounding inputs were the need to refine information flow to farmers on the appropriateness and levels of use of improved inputs and the need to reduce the high costs associated with the use of the inputs. The study identified the main policy issues arising from the impact of maize pricing and marketing policies as: how to stabilize domestic prices in an endeavor to encourage increased production and, simultaneously, put in place a pricing policy that would make maize accessible to consumers; how the private sector could be supported in a bid to develop and improve efficiency in the maize trade; and how the public sector could operate efficiently alongside the private sector with a view to achieving food security and stabilizing supplies through domestic purchases or imports and exports. The study recommended continued research in maize breeding and agronomy as the major basis for the provision of technologies for increased production. In addition to recommending the group method of extension in training the farmers, the study recommended investment in infrastructure and the provision of information by public and private extension services on the benefits of using fertilizers optimally and appropriately to promote small scale producers' use of fertilizers. In order to stabilize maize prices, the study recommended three instruments: buffers stocks publicly held from domestic production, buffer funds through which imports or exports could be varied to offset shifts in domestic availability of maize and compensation funds to deal with shortages and surpluses.

An evaluation of Kenya's self-sufficiency strategy by Nyangito (1998) raised questions on the efficiency of this strategy to achieve food security in maize. The paper reviewed the efficiency of the output maize pricing system for producers and consumers, the competitiveness of maize production using domestic resources and the efficiency of the incentive structure to pursue the self-sufficiency strategy. The efficiency of maize pricing was measured using the Nominal Protection Coefficients (NPC) comparing domestic to border prices of maize while competitiveness of domestic production was measured by the Domestic Resource Costs (DRC). The efficiency of incentive structure was measured using a Policy Analysis Matrix (PAM). The estimated NPCs showed that producer and consumer prices were lower than world markets (meaning inefficiency) but consumers gained at the expense of producers. Kenya was found to have a comparative advantage in the domestic production of maize and was therefore economically competitive in producing maize using domestic resources. The country could therefore save on foreign currency if maize was produced domestically. The pattern of incentives for maize production from the Policy Analysis Matrix (PAM) indicated that maize production was privately and socially profitable – more so for large scale systems than for small scale systems. However, an analysis of output prices showed that the government pricing and trade policies, as well as market failures, depressed domestic prices to below the efficient import parity prices. Further output pricing policy indicated that both small and large scale producers were negatively protected – a disincentive for all producers. Tradable input policy was found to have mixed impacts on producers – favorable for small scale farmers and unfavorable for large scale farmers. Pricing and trade policies was found to be a disincentive for small scale farmers due to import duties and taxes on farm machinery and equipment but an incentive for large scale farmers who enjoyed waivers on import duties and taxes. The study recommended that the government should focus on ways of increasing maize output by removing distortions created by input and output pricing policy, trade policy and market failures all of which create disincentives for producers. While these recommendations were very important, the use of NPC has faced some criticisms. The use of NPCs, though yielding very useful results, suffers one criticism: the requirement to compare domestic and border prices can be a challenge because it is often not obvious what prices to select. Tsakok (1990) notes that one reason for this is the multiplicity of domestic prices for any given commodity. Typically there are numerous domestic prices for a single commodity; for a single market there could be different prices for each season. In addition to there being different locations for producing and consuming regions, there are different locations for producing and consuming regions. The multiplicity of markets, seasons, locations, interest groups, and stages in the life of a commodity requires that price data be adjusted in various ways. One must first decide which economic group one is interested in, and then all the adjustments are made relative to that group. This is a tedious process that can be prone to some errors.

Kibaara (2005) estimated the level of technical efficiency in maize production in Kenya using a Stochastic Frontier Approach. The study also attempted to determine some socio-economic characteristics and management practices which influence technical efficiency in maize production. The study analyzed data using different production functional forms (tanslog, quadratic, transcendental and Cobb-Douglas) and found that the mean technical efficiency of Kenya's maize production was 49 per cent with a distinct intra and inter-regional regional variability in technical efficiency in the maize producing regions. Socioeconomic factors namely number of years of school, age and gender of the household head, health of the household head, and use of tractors all had an impact on efficiency. The study concluded that there was a 51 percent scope for increasing maize production by using the present technology. The study took the largest field as being representative of a typical farm and by so doing reports to have captured 85 percent of the maize area cultivated by farmers in 2003/04. While this explanation was plausible, it would have been useful to compare results across difference planting seasons in order to come up with a more general conclusion of technical efficiency in maize production.

The study by Nyoro et al. (2001) looked at farm level issues that affect production costs and hence the competitiveness of domestic food and commercial production. The study compared the domestic production prices of key food commodities (maize, wheat and sugar) with the equivalent parity prices to assess the extent to which their prices were competitive. Drawing on information gathered from several previous studies, the study drew data from 24 districts in Kenya, regrouped into nine agro regional zones. Household survey information was augmented by updates on farm-based budget information and a market survey conducted in May 2001. The study noted that as maize production moves away from the high maize potential zones, maize productivity decreased to, among other factors, changes in rainfall, altitude, and inputs use. It was noted that in a normal year, the country could supply approximately 60% of its maize consumption at prices below the import parities thus indicating a degree of self-sufficiency. But the rest of the production could only reach consumers at price at or near import parity level, thereby making the country less competitive in maize production as compared with the imports. The study results suggested that due to the low level of maize export prices compared with the actual cost of production, Kenya could not produce and export maize to the world market efficiently even in conditions of excess maize production.

Data from Kenyan and Ugandan production systems were compared to assess competitiveness between the two countries. Maize costs of production per bag and prices received by the Kenyan farmers were found to be about 30% higher than those in Uganda. The study identified several factors which affect production costs and hence influencing maize productivity: machinery costs which affect the quality and timeliness of farm operations; poor quality seeds and increasing seed prices which have acted as a major disincentive to the adoption of high quality maize; declining agricultural input finance; and fertilizer types and adoption rates and quantities. The authors recommended the need for generation and transfer of appropriate cost reduction and productivity enhancing technologies as a key strategy towards reducing local production costs and increasing agricultural productivity to enhance Kenya's competitiveness in agriculture. They underscored the importance of agricultural research to the country's agricultural development, investment in biotechnology, demand driven extension services, and differentiation and grading of agricultural products in this process. This study identified important factors influencing maize productivity but it did not consider the relative weights of each of the identified factors in influencing productivity.

Summary of the Literature

Several studies have been carried out on the maize sub-sector, all looking at the commodity from different perspectives. The study by Kingori (2005) looked at the impact of agricultural trade support in developed countries on maize prizes in Kenya by analyzing how prices are transmitted from OECD countries to the domestic market in Kenya. The study used a Vector Auto regression (VAR) model to analyze price transmission and found that domestic maize prices in Kenya are affected by maize imports from OECD countries. A similar model was used by Jayne et al (2005) to estimate the effects of government policy on wholesale maize prices and their volatility in Kenya. The study found that NCPB's operations raise wholesale market prices while the import tariff exerts only modest effects on open market maize price levels. A comparison of the competitiveness of Kenyan and Ugandan Maize Production was carried out by Nyoro et al., (2004). The study concluded that poor crop husbandry, high cost of farm inputs and machinery, seed quality and a weak extension system were the main contributors of the high cost of Kenyan maize production and recommended more concerted efforts into maize technology generation, diffusion and quality control policies if Kenya wished to compete with neighboring countries. Nyangito (1997) reviewed and evaluated the impact of the policies used over the years in a bid to identify the main policy concerns in the maize sub-sector that need to be addressed. The identification, the study noted, would help the stakeholders overcome the constraints in the production and the marketing of maize. An evaluation of Kenya's self-sufficiency strategy by Nyangito (1998) raised questions on the efficiency of this strategy to achieve food security in maize. The study recommended that the government should focus on ways of increasing maize output by removing distortions created by input and output pricing policy, trade policy and market failures all of which create disincentives for producers. Kibaara (2005) estimated the level of technical efficiency in maize production in Kenya using a Stochastic Frontier Approach. The study also attempted to determine some socio-economic characteristics and management practices which influence technical efficiency in maize production. Socioeconomic factors namely number of years of school, age and gender of the household head, health of the household head, and use of tractors all had an impact on efficiency. The study concluded that maize production was only 49 percent efficient; there is hence a 51 percent scope for increasing maize production by using the present technology. The study by Nyoro et al. (2001) looked at farm level issues that affect production costs and hence the competitiveness of domestic food and commercial production. The study identified several factors which affect production costs and hence influencing maize productivity: machinery costs which affect the quality and timeliness of farm operations; poor quality seeds and increasing seed prices which have acted as a major disincentive to the adoption of high quality maize; declining agricultural input finance; and fertilizer types and adoption rates and quantities. This study identified important factors influencing maize productivity but it did not consider the relative weights of each of the identified factors. The present study therefore seeks to build on the work done by Nyoro et al., 2001 to assess the significance of the identified factors. This study takes the view that machinery costs, the seed prices, and use of fertilizer are all influenced by the exchange rate. The study also attempts to include some important factors that may have been omitted by previous studies such as the exchange rate, macroeconomic environment and the political environment.

CHAPTER THREE - METHODOLOGY

The efficacy of the price system in agricultural production remains intact, but the overbearing concern that once 'prices are right' farmers will increase their output requires that studies be continually carried to establish supply response to both price and non-price factors especially for developing countries. Coleman and Young (1989) suggest that the supply of an agricultural product to the market will depend on the price of the product, the prices of competing products, the prices of joint products, the prices of inputs, the state of technology, the natural environment and the institutional setting. This study seeks to analyze the price and non-price determinants of maize production in Kenya. In a bid to be more comprehensive, identification of factors affecting maize production in this study is along the lines suggested by Coleman and Young (1989). These are: the price of the product; the prices of inputs (measured by the exchange rate); the state of technology (the quality of seeds), the natural environment (prior period yield, macroeconomic environment, weather and whether or not there is civil unrest); and the institutional setting (measured by credit to the agricultural sector).

In the simplest model, farmers are assumed to take as their expected price, the price received in the previous production period. In this study it is assumed that farmers are rational producers who respond to economic opportunities and will be therefore respond positively to price changes and will also be influenced by the prior period's yield in determining production for the current year. The exchange rate is selected because it will influence the cost of inputs such as machinery and fertilizer necessary for increased output. The quality of seed affects output and hence productivity. It is noted that prior to liberalization of the maize sector, the sale of seeds was controlled hence quality was assured. The study will assess whether there is a change in the quality of seed after liberalization. Rainfall is one of the most important natural resources for countries dependent on agriculture. The study will assess the impact of reduced rainfall (drought) on maize production. The macroeconomic environment will be gauged by the GDP growth rate. This will be lagged because the assumption is that a good macroeconomic environment will encourage increased production in the following year because farmers are confident that they will get a good market for their produce. It is also expected that farmers will respond positively to a good yield in the prior period. The study aims to find out whether or not a situation of civil unrest and drought influences maize production. This is based on the assumption that civil unrest and drought disrupt agricultural production. It is thus expected that in a year experiencing civil unrest and drought, farmers' lives will be disrupted and hence reduced production. Finally, limited credit to the agricultural sector dampens production because resource poor farmers cannot purchase the required inputs to improve their farms.

3.1 MODEL SPECIFICATION

Coleman and Young (1989) recommend that a dynamic approach, which recognizes time lags in agricultural supply responses, should be adopted in empirical analysis. There are two major approaches in modeling time-series supply elasticities. The first is the aggregate input demand elasticities (Mazivila, 2002). This is an indirect method of estimating aggregate supply elasticity of output by aggregating over the product of the elasticity of supply of inputs and the elasticity of demand of inputs (Chibber, 1989 as quoted in Mazivila, 2002). The second is supply functions which is a direct method. Due to this, the present study deals with agricultural supply responses, the use of supply functions will be applied.

Of the models used in the study of farmer supply response to prices and other incentives, one of the most widely used is the model advanced by Marc Nerlove based on his seminal work of 1958.

The simple Nerlovian Model basically consists of three equations:

$$A^*_t = \alpha_0 + \alpha_1 P^*_t + \alpha_2 Z_t + U_t \quad (3.1)$$

$$P^*_t = P^*_{t-1} + \beta (P_{t-1} - P^*_{t-1}) \quad (3.2)$$

$$A_t = A_{t-1} + \gamma (A^*_t - A_{t-1}) \quad (3.3)$$

Where A_t and A^*_t are actual and desired area under cultivation (or sometimes output or yield) at time *t*, P_t and P^*_t are actual and expected price at time *t* and β and γ are the expectation and adjustment coefficients respectively. Z_t represents other exogenous factor(s) affecting supply at time *t*.

There are, however, differences in the way the model has been employed in actual empirical work (Askari and Cummings, 1977). Most of these distinctions can be grouped in three categories: modifications affecting the variables used by Nerlove, inclusion of factors of particular interest in the situation under investigation (corresponding to the variable Z in equation 3.1) and attempts to represent quantitatively situations not considered by Nerlove – primarily perennial and/or slow-maturing crops and livestock.

One of the modifications is presented in the Adjusted Model, which argues that a better proxy for farmer's intentions is given by the areas that the farmer would have planted 'in the absence of adjustment constraints' such as institutional and technological constraints. In the absence of technological and institutional constraints, $A^*_t = A_t$ Solving for A^*_t in equation 3.3 yields:

$$A^*_t = \frac{1}{\gamma}(A_t) - \left[\frac{1-\gamma}{\gamma}\right](A_{t-1}) \qquad (3.4)$$

Substituting 3.4 into 3.1 we have:

$$\frac{1}{\gamma(A_t)} - \left[\frac{1-\gamma}{\gamma}\right](A_{t-1}) = \alpha_0 + \alpha_1 P^*_t + \alpha_2 Z_t + U_t$$

This can be re-written as:

$$A_t = \alpha_0\gamma + \alpha_1\gamma P^*_t + (1-\gamma)A_{t-1} + \alpha_2\gamma Z_t + \gamma U_t \qquad (3.5)$$

Substituting equation 3.2 into 3.5 we get:

$$A_t = \alpha_0\gamma + \alpha_1\gamma[\ P^*_{t-1} + \beta(P_{t-1} + P^*_{t-1})\ ] + (1-\gamma)A_{t-1} + \alpha_2\gamma Z_t + \gamma U_t$$

which can be further simplified as:

$$A_t = \alpha_0\gamma + \alpha_1\gamma\beta P^*_{t-1} + \alpha 1\gamma(1-\beta P^*_{t-1}) + (1-\gamma)A_{t-1} + \alpha_2\gamma Z_t + \gamma U_t \quad (3.6)$$

Askari and Cummings (1977) note that output statistics have been incorporated in supply analyses in various ways: output measured in terms of crop weight or volume produced or marketed; planted and harvested acreage. However, it can be argued that farmers do not really adjust the area planted to price fluctuations; rather they adjust the desired output. In this regard, we take a general supply function in the form:

$$A^*_t = f\,(PPR, Z_t) \quad (3.7)$$

Where Z_t = (CR, CVL, EXRATE, GDP, SQ, YLD, WT)

A^*_t is the area expected to be harvested in time *t* measured in hectares

PPR is the producer price in Kshs. received by the farmer for a 90kg bag of maize

CR is the measure of credit to the agricultural sector. The lending rate is used as a proxy

CVL is civil unrest which represents political environment and is introduced as a dummy variable where 1 is a year experiencing civil unrest and 0 is a year with no civil unrest

EXRATE is the exchange rate which affects to the cost of machinery and fertilizers

GDP is the annual rate of growth of the gross domestic product used to assess the macroeconomic environment

SQ is the quality of the seed which is introduced as a dummy variable for the period before and after liberalization of the maize sector. 1 is the period prior to liberalization (1996) and 0 is the period after liberalization, and

YLD is the maize yield calculated as total output in tons divided by area harvested in hectares

WT is the weather dummy variable where 1 is a period of drought and 0 is the period of no drought

However, the expected area A^*_t cannot be observed. The area harvested in terms of observable variables is given as:

$$A_t = A_{t-1} + \gamma(A^*_t - A_{t-1}) \quad (3.8)$$

Where A_t is the actual area harvested in time *t*

γ is the adjustment coefficient representing the effects of technological and institutional constraints on the farmer; $0 \leq \gamma < 1$

Equation 3.8 implies that area actually harvested in period (*t*) equals area actually harvested in the previous period (t-1) plus an adjustment term proportional to the difference between the area that farmers intend to harvest now and the area harvested in the previous period. If we re-write equation 3.8 in terms of A^*_t, we get:

$$A^*_t = \frac{1}{\gamma}(A_t) - \left[\frac{1-\gamma}{\gamma}\right](A_{t-1}) \quad (3.9)$$

Assuming that $\gamma = 1$ meaning there are no constraints on the farmer, and substituting 3.9 into 3.7 we get:

$$A_t = f(PPR, Z_t)$$

However, an important characteristic of agricultural production is the time lag involved in it. Outputs are obtained months after planting season and after planting, farmers have comparatively little control to affect output. Therefore, since the actual price is not known at the time of planting and yield cannot be determined a priori, we expect that farmers will be guided by the previous period prices as well as previous period yield and previous period macroeconomic environment. The final supply function therefore becomes:

$$A_t = f(PPR_{t-1}, CR, CVL, EXRATE, GDP_{t-1}, SQ, YLD_{t-1}, WT) \quad (3.10)$$

Estimation of the above function may result in residuals that violate the assumption of normality of the error terms. This is a simplifying assumption of the classical normal linear regression and must be satisfied for the method of ordinary least squares to be the best linear unbiased estimator. To ensure normality of the residuals, the estimation equation used in the study is expressed in logarithmic form. The transformation is justified because it ensures that the errors are both homoskedastic and normally distributed (Leaver, 2004).

The long run equation to be estimated is therefore:

$$A_t = a_0 + a_1 \ln PPR_{t-1} + a_2 \ln CR + a_3 CVL + a_4 \ln EXRATE + a_5 \ln GDP_{t-1} + a_6 SQ + a_7 \ln YLD_{t-1} + a_8 WT + \mu_t \qquad (3.11)$$

Where μ_t is the error term.

Equation 3.11 does not assume the presence of cointegration. If the series are however found to be cointegrated, it will be necessary to use a vector error correction model. To establish the presence of cointegration, it will be necessary to carry out various tests as highlighted in the next section.

3.2 DIAGNOSTIC TESTS

Normality Tests

Most economic data series are highly skewed. This could possibly be due to the fact that data have a clear floor but no definite ceiling. It will therefore be important to examine whether the data exhibit normality. In small or finite samples, the assumption of normality is checked using the *t*, F and Chi-Square tests. For this study, the Jarque-Bera Normality test will be employed. The test statistic measures the difference of the skewness and kurtosis of the series with those from the normal distribution. The statistic is computed as:

$$\text{Jarque} - \text{Bera} = \frac{N}{6}\left(S^2 + \frac{(K-3)^2}{4}\right)$$

where S is the skewness, and K is the kurtosis.

Under the null hypothesis of a normal distribution, the Jarque-Bera statistic is distributed as χ^2 with 2 degrees of freedom. The reported probability is the probability that a Jarque-

Bera statistic exceeds (in absolute value) the observed value under the null hypothesis- a small probability value leads to the rejection of the null hypothesis of a normal distribution.

Stationarity Tests

Most time series data tend to be non-stationary meaning that they are likely to be trended or integrated. This implies that the variables may have a mean that changes with time and a non-constant variance. The use of such variables in the regression equation would increase the chances of spurious results and no inference can be done since statistical tests like the F-distribution or the t-distribution are invalid. For this reason, all variables will be tested for stationarity and order of integration.

Unit Root tests

Unit roots test for the significance of the value of ρ against the null hypothesis that Ho;ρ=0. The unit root tests that will be employed in this study are the Augmented Dickey Fuller (ADF) test and the Philips Perron test. The ADF test runs an equation of the following form, for a given variable X.

$$X_t = \delta + \rho X_{t-1} + \sum_{i=1}^{k} c_i \Delta X_{t-1} + \mu_t$$

Where ΔX denotes the first differences of the series and t is the current time period measured in years. In testing for unit roots, the null hypothesis H_0;p=0 states that the series has a unit root. Failure to reject this hypothesis confirms the presence of non-stationarity. In this case, we accept the alternative hypothesis H_a; $p<0$. If we reject the null hypothesis then it means the series is stationary.

The decision rule is that if t*> ADF critical value then we do not reject the null hypothesis. This means that unit root exists. However if t*< ADF critical value, we reject the null hypothesis meaning that unit root does not exist. The test stops as soon as one is able to reject the null hypothesis of a unit root. If the computed t-ratio of the p-coefficient is lower than the critical value from the DF tables, the variable is said to be stationary and integrated of order 0. The study will compare the results of the ADF tests against the Philips-Perron test to confirm validity of the results. If the variables are found to be integrated of the same order, we will proceed to test for cointegration.

Cointegration Testing

The presence of a unit root implies that regression involving the series can falsely imply the existence of a meaningful economic relationship. Variables are cointegrated if a linear combination of these variables assumes a lower order of integration individually; i.e. they are individually non-stationary, integrated of the same order but their linear combination is integrated of a lower order (Thomas, 1997).

The purpose of cointegration testing is to determine whether a group of non-stationary series is cointegrated or not. There are two possible methods for testing for cointegration: the Engle-Granger Test and the Johansen Procedure. A major drawback of the Engle-Granger tests stems from the fact that where there are more than two variables in a model, there may exist more than one cointegrating vector. Engle-Granger test for cointegration cannot distinguish between several cointegrating vectors and linear combination of these vectors. In order to distinguish between more than one cointegrating vectors amongst several variables, the study will apply the more powerful Johansen Procedure for cointegration that is based on a likelihood statistic, with the null hypothesis of no cointegration. The procedure determines both the number of cointegrating vectors and provides estimates of these vectors together with estimates of the adjustment parameters. The method first tests the hypothesis of no cointegrating vectors ($r=0$). If this cannot be rejected, it is then possible to test the hypothesis that there is at most one cointegrating vector ($r\leq1$) (Thomas, 1997). To determine the number of cointegrating relations, r, in the system, the study will invoke the iterative procedure called the Johansen Trace test that is based on a Likelihood Ratio statistic and with the null hypothesis of no cointegration. The presence of a cointegrating relation will form the basis of the Vector Error Correction specification.

Error Correction Model

The error correction specification does not only facilitate the analysis of the short run effects on the dependent variable, but also suggests the speed of adjustment to long-run equilibrium and permits an equilibrium interpretation of the estimates.

A vector error correction (VEC) model is a restricted vector autoregression (VAR) designed for use with nonstationary series that are known to be cointegrated. The VEC has cointegrating relations built into the specification to ensure that it restricts the long run behaviors of the explanatory variables to converge to their cointegrating relationships while allowing for short run adjustment dynamics. The cointegrating terms is the error correction terms since the deviations from the long run equilibrium are corrected gradually through a series of partial short run adjustments. The short-run equation will therefore be:

$$\Delta A_t = a_0 + a_1 \Delta \ln PPR_{t-1} + a_2 \Delta \ln CR + a_3 \Delta CVL + a_4 \Delta \ln EXRATE + a_5 \Delta \ln GDP_{t-1}$$
$$+ a_6 \Delta SQ + a_7 \Delta \ln YLD_{t-1} + a_8 WT + a_9 ECT_{t-1} + \mu_t$$

(3.12)

Where ECT_{t-1} is the error correction term and Δ represents the difference operator while μ_t is the disturbance term. The long run equation 3.11 is re-presented below.

$$A_t = a_0 + a_1 \ln PPR_{t-1} + a_2 \ln CR + a_3 CVL + a_4 \ln EXRATE + a_5 \ln GDP_{t-1}$$
$$+ a_6 SQ + a_7 \ln YLD_{t-1} + a_8 WT + \mu_t$$

3.3 *CHOICE OF VARIABLES AND EXPECTED SIGNS*

Dependent Variable

In estimating a supply function, the choice of the best proxy for the dependent variable must be carefully considered. Whereas quantity supplied would be presumed the best proxy due to the relationship between quantity and price, this variable may not provide the best results in the estimation. This is primarily because quantity supplied often includes subsistence food provisions which may not necessarily be wholly a function of price but possibly determined by food self sufficiency reasons as well. The most suitable proxy for farmers' intended output can be given by acreage planted. Acreage planted is preferred to output for the reason that the latter also fails to reflect planned production decisions of farmers because of its susceptibility to weather variability. The use of acreage planted as the dependent variable is well documented in other studies including those by Alemu *et. al.* (2003), Mazivila (2002) and Kutha (2007). Acreage will therefore be the dependent variable in this study.

Producer Price

This is the primary independent variable in the model to be estimated. Price is deemed an important factor in determining farmers' decisions to produce maize or otherwise. The assumption that farmers respond positively to price and market incentive confirms that price is an important variable in this study. The variable is measured in Kenya Shillings per 90kg bag which is the standard bag that is accepted by the National Cereals and Produce Board (NCPB) and whose price is reported in official government statistics. Price is expected to have a positive impact on total output. The NCPB is the largest buyer of maize from farmers hence the choice of the price.

Credit to the Agricultural Sector

Credit is important for assisting farmers to purchase farm implements as well as expand the area harvested. Where credit is limited, this is likely to result in reduced output. For this study, the nominal lending rate is used as a proxy for credit to the agricultural sector and the variable is expected to have a positive sign.

Civil Unrest

The political environment is gauged by civil unrest. In a situation of civil unrest, it is expected that production will be disrupted. The civil situation is introduced as a dummy variable where 1 is a year where the country experiences civil unrest and 0 is a year with no civil unrest. An inverse relationship is expected between this variable and the dependent variable.

Exchange Rate

The exchange rate affects the cost of farm inputs that have to be imported. This includes tractors and other machinery as well as fertilizers. The variable is the exchange rate of the Kenya Shilling to the US dollar. An unfavorable exchange rate (i.e. when the local currency is weak compared to the US dollar) is therefore likely to have a negative impact on total output. Conversely, an appreciation of the Kenya Shilling is therefore expected to have a positive impact on maize production.

Gross Domestic Product

The annual growth rate of the gross domestic product is used to assess the effects of the macroeconomic environment on maize production. The relationship is expected to be positive.

Seed Quality

Since liberalization of the maize sector, farmers are increasingly encountering the sale of fake seeds in the market. This variable is introduced as a dummy variable to assess whether there are any changes on overall production of maize since liberalization where 1 is the period before liberalization and 0 is the period after liberalization.

Yield

Yield is expected to have a positive impact on maize production since a good yield in the previous year is likely to encourage increased cultivation in the current period and vice versa.

Weather

Weather is a significant factor in any agricultural production. Adequate rainfall is a crucial factor without which annual maize output could be significantly compromised. This variable is introduced as a dummy variable for drought where 1 is a year in which the country experiences little rainfall and hence drought and 0 is a period of no drought.

3.4 DATA SOURCES

The study makes use of annual time series data for the period 1963-2006. Gaps in available data resulted in collection of data from various sources. Data on rainfall, prices and area harvested were obtained from the data compendium for Kenya's agricultural sector assembled by the Kenya Institute for Public Policy Research and Analysis (KIPPRA) derived from various government publications including the Economic Surveys, Statistical Abstracts and data from the Ministry of Agriculture. Owing to the fact that data covered only period the period up to 2001, data for the remaining years up to 2006 was derived directly from various issues of Economic Surveys and Statistical Abstracts published by the Central Bureau of Statistics. It is not expected that there would be variations in both sets of data as they are derived from the same sources. Data on lending rates, GDP and exchange rates were obtained from the International Financial Statistics (IFS) year books. Similarly, because this data did not cover the entire study period, the missing data was updated from various issues of Economic Surveys and Statistical Abstracts. Because of differences in data collection techniques, methodological issues, focus, and timing, data from the two different sources may differ. However, the data published in IFS by the IMF Statistics Department come from member country statistical authorities (e.g., central bank, finance ministry, etc.) so no major variations are expected.

CHAPTER FOUR - REGRESSION RESULTS

In this chapter, we present the descriptive statistics as well as interpret the regression results. We begin by presenting the descriptive statistics.

4.1 Descriptive Statistics

Many statistical tests and intervals depend on normality assumptions. An analysis of the descriptive statistics can enable us determine the variables that are close to normal distribution. We use the mean, median, skewness and kurtosis to describe the data which are summarized in the Table 3 below.

Table 3: Characteristics of the Data

	LN_ARHRV	LN_CR	LN_EXRATE	LN_GDP	LN_PPR	LN_YLD
Mean	7.185982	2.640332	2.909576	1.275238	5.231133	0.273953
Median	7.177782	2.613007	2.758743	1.526056	5.164786	0.386673
Maximum	7.543358	3.590163	4.364372	2.674149	7.336546	0.826679
Minimum	5.846439	2.197225	1.931521	-1.609438	3.178054	-1.117033
Std. Dev.	0.353989	0.428674	0.955293	0.800461	1.476606	0.443987
Skewness	0.974666	0.702820	0.414574	-1.522904	0.154353	-1.214652
Kurtosis	1.823128	2.375487	1.520537	5.879862	1.563774	4.272272
Jarque-Bera	5.132580	4.238793	5.153366	31.48056	3.866497	13.47369
Probability	0.085300	0.120104	0.076026	0.000000	0.144677	0.001186
Sum	304.6972	113.5343	125.1118	54.83523	224.9387	11.77996
Sum Sq. Dev.	5.262933	7.717988	38.32857	26.91102	91.57534	8.279215
Observations	43	43	43	43	43	43

In normally distributed data, the mean and the median should be equal. For the variables in this study, there is none for which the mean and the median are equal indicating that they are not normally distributed. The mean is typically higher than the median in positively skewed distributions and lower than the median in negatively skewed distributions. This is confirmed for area harvested, credit, exchange rate and producer prices where we find that the mean is higher than the median and hence positively skewed. For the other variables, the mean is lower than the median hence negatively skewed.

Skewness is a measure of symmetry, or more precisely, the lack of symmetry. The histograms contained in appendix 1 give us a graphical view of the skewness of the variables. The skewness for a normal distribution is zero. None of the variables has skewness with the value of zero thereby further confirming that they are not normally distributed. The natural logarithms of GDP and yield all have negative skewness. The histograms confirm that the data have the tail of the distribution on the left. For area harvested, credit, exchange rate and producer prices, we have positive skewness with the right tail being longer than the left.

Kurtosis is a measure of whether the distribution is peak or flat relative to a normal distribution. Datasets with high kurtosis tend to have a distinct peak near the mean, decline rather rapidly, and have heavy tails. Data sets with low kurtosis tend to have a flat top near the mean rather than a sharp peak. A uniform distribution would be the extreme case. Kurtosis is also a measure of how outlier-prone a distribution is. The kurtosis of the normal distribution is 3. Distributions that are more outlier-prone than the normal distribution have kurtosis greater than 3 while distributions that are less outlier-prone have kurtosis less than 3. The kurtosis is higher for GDP and yield meaning that they have a peak at the mean and long tails. The kurtosis for area harvested, credit, exchange rate and producer prices is below three but we can say that they are moderately skewed and have less outliers.

The standard deviation is the most common measure of statistical dispersion, measuring how widely spread the values in a dataset are. If many data points are close to the mean, then the standard deviation is small; if many data points are far from the mean, then the standard deviation is large. If all the data values are equal, then the standard deviation is zero. For the variables in this study, the standard deviations are small (below 1.5). This means that there are small variations in the data set.

Finally the Jarque-Bera (JB) test was used to check for normality in the variables. The test is distributed as Chi Square with two degrees of freedom, and therefore has critical values of: $\chi^2_{.05} = 5.991$ and $\chi^2_{.01} = 9.210$ at 5% and 1% respectively. The test statistic measures the difference of the skewness and kurtosis of the series with those from the normal distribution. It tests the null hypothesis that the data are from a normal distribution. A significant p-value (JB calculated value is greater than the critical value) leads to the rejection of the null hypothesis of normal distribution. Based on Jarque-Bera statistics area harvested, credit to the agricultural sector and producer prices are not significant. We therefore do not reject the null of normality. The test further shows that except for area harvested and exchange rate which are significant at the 10% level, the calculated values for all variables are all significant at the 5% and 1% levels therefore we reject the null hypothesis of a normal distribution and confirm the findings already described above.

Correlation tests are used to show collinearity between independent variables. The correlation results for the variables used in the analysis are displayed in the table below.

Table 4: Correlation Results

	LN_ARHRV	LN_CR	LN_EXRATE	LN_GDP	LN_PPR	LN_YLD
LN_ARHRV	1.000000	0.555195	0.627953	-0.263957	0.713391	0.708885
LN_CR	0.555195	1.000000	0.818430	-0.545683	0.834670	0.606369
LN_EXRATE	0.627953	0.818430	1.000000	-0.479372	0.969516	0.578560
LN_GDP	-0.263957	-0.545683	-0.479372	1.000000	-0.416620	-0.240702
LN_PPR	0.713391	0.834670	0.969516	-0.416620	1.000000	0.704338
LN_YLD	0.708885	0.606369	0.578560	-0.240702	0.704338	1.000000

The results show that GDP is negatively correlated with all variables. According to Gujarati (2003), multicollinearity becomes a serious problem if the parwise or zero-order correlation coefficient between two regressors is in excess of 0.8. The correlation coefficients between the exchange rate variable and credit to the agricultural sector as well as producer prices is in excess of 0.8 as is the coefficient between credit to the agricultural sector and producer prices. In running the final regression, the effects of dropping one of these variables will be considered.

4.2 *Unit Root Tests*

The graphical analysis presented in Appendix 2 suggests non-stationarity of the data. The results of the ADF and PP tests in Table 4 show that all variables become stationary after the first difference. This shows that the variables in level form are integrated of order 1. The graphical analysis of the first differences of the variables is shown in Appendix 3.

Table 5: Results of the Unit Root Tests

	ADF-Test		PP-Test	
Variable	Levels	1st Difference	Levels	1st Difference
LN_ARHRV	-2.365698	-6.095358	2.023422	-5.864760
	(0.3915)	*(0.0000)*	*(0.9885)*	*(0.0000)*
LN_CR	-0.438534	-5.186663	0.225830	-5.160054
	(0.9828)	*(0.0007)*	*(0.7470)*	*(0.0000)*
LN_EXRATE	-2.134399	-7.337396	2.179242	-6.571435
	(0.5126)	*(0.0000)*	*(0.9920)*	*(0.0000)*
LN_GDP	-3.893174	-7.184084	-1.490691	-13.27715
	(0.0218)	*(0.0000)*	*(0.1256)*	*(0.0000)*
LN_PPR	-2.433004	-6.1177555	3.065275	-5.061823
	(0.3583)	*(0.0000)*	*(0.9992)*	*(0.0000)*
LN_YLD	-3.644267	-8.132383	-2.092362	-6.969469
	(0.0376)	*(0.0000)*	*(0.0363)*	*(0.0000)*

*p-values are in the parentheses

4.3 *Cointegration Tests*

To test for cointegration, first we run an OLS regression of the dependent variable in level form on the independent variables in levels. Since all the variables are integrated of order 1 we expect the residuals to be integrated of order zero if they are cointegrated i.e. they are stationary. The graphical presentation in Appendix 4 shows that the residuals fluctuate around the mean indicating stationarity. Since all the explanatory variables were found to be integrated of the same order, they could potentially be cointegrated. If that is the case, it means that a long-run relationship exists among them. The Johansen

Cointegration test was used to test for cointegration. The results are shown in Table 6 below.

Table 6: Johansen Cointegration Test Results

Hypothesized No. of CE (s)	Trace Statistic	5% CV	p-value**	Maximum Eigenvalue Statistic	5% CV	p-value
r = 0* (none)	129.8983	95.75366	0.0000	52.20575	40.07757	0.0014
r ≤ 1* (at most 1)	77.69259	69.81889	0.0103	28.13411	33.87687	0.2074
r ≤ 2* (at most 2)	49.55848	47.85613	0.0343	25.78323	27.58434	0.0835
r ≤ 3 (at most 3)	23.77525	29.79707	0.2101	16.65672	21.13162	0.1888

Note: r is the number of cointegrating relations under the null hypothesis of no cointegration.

* denotes rejection of the hypothesis at the 0.05 level

** MacKinnon-Haug-Michelis (1999) p-values

The trace statistic tests the null hypothesis of r cointegrating relations against the alternative of k cointegrating relations, where k is the number of endogenous variables, for r=0,1,....,k-1. The maximum eigenvalue statistic tests the null hypothesis of r cointegrating relations against the alternative of $r + 1$ cointegrating relations. The trace test indicates at least three cointegrating equations at the 5% level while the maximum eigenvalue indicates one cointegrating equation at the 5% level. The calculated trace statistic is greater than the 5% critical value, hence we reject the null hypothesis of no cointegration and we accept the alternative of existence of at most three cointegrating vectors. In light of this, the empirical model to be estimated is a restricted vector autoregression (VAR) with three cointegrating relationships. The estimated cointegrating relations are:

$$LN\_ARHRV = 2.3539LN\_CR - 0.72385LN\_EXRATE + 0.44577LN\_GDP$$
$$-0.26349LN\_PPR + 0.088840LN\_YLD$$

$$-0.19037LN\_ARHRV = LN\_CR - 0.22709LN\_EXRATE - 0.11118LN\_GDP$$
$$-0.22092LN\_PPR + 0.39369LN\_YLD$$

$$1.4341LN\_ARHRV = -1.3373LN\_CR + LN\_EXRATE - 0.88089LN\_GDP$$
$$-0.664416LN\_PPR + 0.92261LN\_YLD$$

(3.13)

The three ECM terms were estimated alongside the first difference on the non-stationary model to establish both the short-run and long-run relationships and the speed of adjustment to long-run equilibrium by making use of cointegration and the ECM.

4.4 Long-run regression results

In estimating the long run equation, the effect of including all variables was checked against the possibility of dropping exchange rate and credit to the agricultural sector variables from the model due to evidence of collinearity as shown by the correlation coefficients in Table 4 above. Inclusion of the two variables indicated the presence of serial correlation and it was therefore deemed necessary to drop them. It was considered appropriate to drop the exchange rate variable especially because most maize producers are small scale farmers who may not purchase large farm machinery or commercial fertilizers and thus be affected by the exchange rate. Instead, they rely on family labour and also use animal manure which they gather from their farms. It was also possible to drop credit because although it is important for assisting farmers to purchase of various farm inputs, there is no foundation in producer theory for credit to be an input (Barrett, 2004). Some outliers noted in the dependent variable were resolved by adding dummy variables for the outlier years 1964, 1965 and 1967. Three other dummy variables were added to the model to capture the impact of various shocks in the economy. Increased macroeconomic instability arising prior to the 1992 general elections resulted in excess liquidity in the economy. This excess liquidity together with an ensuing financial scandal led to a major depreciation of the Kenyan Shilling in 1993 hence the first dummy. The effects of liberalization in 1994 explain the second dummy. The third dummy takes care of an unprecedented negative growth rate in GDP in 2000. The following are the results of the long run regression.

Table 7: Results of the long-run regression

Variable	Coefficient	Standard Error
Constant	1.39262***	0.4051
Natural logarithm of Acreage (previous period)	0.787481***	0.06350
Natural logarithm of GDP (previous period)	-0.00530309	0.02742
Natural logarithm of Producer Prices (previous period)	0.0290011*	0.02599
Natural logarithm of Yield (prior period)	-0.0192587**	0.05385
Civil unrest	0.00669606	0.02545
Seed Quality	0.0259417	0.05987
Dummy variable for Drought	-0.0525453*	0.02976
Dummy variable for 1964	-0.570911***	0.08118
Dummy variable for 1965	-0.498474***	0.08536
Dummy variable for 1967	0.397706***	0.08768
Dummy variable for 1993	-0.0966979	0.08253
Dummy variable for 1994	0.0285453	0.09810
Dummy variable for 2000	-0.0208298	0.07331
Test Summary		
Sigma		0.0585542
Residual Sum of Squares (RSS)		0.078857675
R-Squares (R^2)		0.981749
F-Test		(13,23) = 95.17 [0.000]**
Log-likelihood		61.2933
DW		2.48
no. of observations		37
no. of parameters		14
mean(LARHRV)		7.05485
var(LARHRV)		0.116776
AR 1-2 test:		F(2,21) = 3.5327 [0.0476]*
ARCH 1-1 test:		F(1,21) = 0.31631 [0.5798]
Normality test:		Chi^2(2) = 9.5113 [0.0086]**
Hetero test:		F(17,5) = 0.22574 [0.9909]
RESET test:		F(1,22) = 2.9294 [0.1010]

Levels of significance: * 1%; ** 5%; *10%**

Diagnostic tests carried out on the model did not reveal any serious problems. The F-test value of F (13,23) = 90.45 [0.000]** is highly significant; thus, the hypothesis of a significant relationship between dependent variable (area harvested) and the independent variables is validated. The error autocorrelation test (AR Test) is significant at the 5% level, suggesting that there is evidence of serial correlation in the residuals. For this reason, it was necessary to carry out tests on the significance of the Durbin Watson statistic to confirm the presence of serious serial correlation. In our case, the DW*=(4-DW) =1.52 which is then compared to the lower and upper critical value bounds of Q_L=1.217 and Q_U of 1.322. Where DW*>Q_U, as is the case here, we confirm that there no serious negative serial correlation. The ARCH test which is the autoregressive conditional heteroscedasticity is not significant. The Heteroscedasticity test using squares is also not significant hence we do not reject the null of unconditional homoscedasticity. Finally, the RESET test which tests the null of correct specification of the original model against the alternative that powers of $\hat{y}_t$ have been omitted is not significant meaning that the model is correctly specified. All in all, we find that the explanatory variables in the model explain 98% of the variations in the dependent variable.

The results of the regression show that in the long run, acreage under production in the previous period, previous period yield, drought and previous period producer prices are all significant. The 1964, 1965 and 1967 dummy variables are also significant. The coefficients of acreage and producer prices are positive meaning that increases in these variables would result in an increase in maize production in the long run. The coefficient of the previous year yield is negative and significant. This means that reduced yield in the previous period will induce farmers to try and produce more in the next period. The drought dummy variable is also significant in the long run and has the expected negative sign. The significance of the 1964 and 1965 dummy variables is rooted in the Swynnerton Plan (1954) which envisaged substantial increases in crop and livestock production and advocated continuation of soil conservation programmes linked strongly to income generation. The impact of this effort was evident in the early to mid 1960s with dramatic increases in marketed output of small farm areas. Furthermore, it can be recalled that immediately after independence, the government put in place a land settlement scheme where farmers were not only given land, they were also provided with inputs to carry out farming operations including generous loans. Many of the farms continue to be the large maize producing areas of Kenya today. The significance of the 1967 dummy can be linked to Kenya's first Development Plan (1966-1970) which accepted as a necessary prerequisite for development, the reform of land tenure by registration of titles and consolidation of fragmented holdings which led to increased productivity. In addition, it is in 1967 that a new substantive Land Control Act (revised in 1968 and several times thereafter) was passed to control transactions in agricultural land and under which the land market is currently regulated. The Act spells out the jurisdiction of Land Control Boards and Land Control Areas and as well as outlines the legislation for control in dealings in agricultural land.

4.5 Short-run regression results

In this section we analyze the short-run dynamic equation. As in the long run equation, exchange rate and credit to the agricultural sector were dropped from the final model. Removal of irrelevant lags and insignificant variables yielded a preferred model contained in Table 8 below.

Table 8: Short-run regression results

Variable	Coefficient	Standard Error
Constant	5.22197***	1.319
Δ Natural logarithm of Acreage t_1	-0.305850*	0.1496
Δ Natural logarithm of Acreage t_2	-0.857513***	0.2051
Δ Natural logarithm of Acreage t_3	-0.202622	0.1629
Δ Natural logarithm of Acreage t_4	-0.275662**	0.1084
Δ Natural logarithm of GDP t_1	0.0789374*	0.04077
Δ Natural logarithm of GDP t_2	0.143160***	0.03918
Δ Natural logarithm of GDP t_3	0.0651027*	0.03054
Δ Natural logarithm of GDP t_4	-0.0313401	0.03098
Δ Natural logarithm of Producer Prices t_2	-0.166571*	0.08564
Δ Natural logarithm of Producer Prices t_3	-0.0191622**	0.08506
Δ Natural logarithm of Producer Prices t_4	-0.162926*	0.07533
Δ Natural logarithm of Yield t_1	-0.0839355	0.1260
Δ Natural logarithm of Yield t_2	-0.415178***	0.1128
Δ Natural logarithm of Yield t_3	-0.212118*	0.1125
Δ Natural logarithm of Yield t_4	0.0754692	0.1036
Civil Unrest	0.0217427	0.02753
Seed Quality	-0.0820537*	0.04156
Dummy variable for Drought	-0.0517945*	0.02529
Dummy variable for 1993	0.0804471	0.1111
Dummy variable for 1994	0.202245*	0.1024
Error Correction Term (ECM_{t_1})	-117095*	0.05614
Error Correction Term (ECM_{t_2})	2.75014e-005***	8.192e-006
Test Summary		
Sigma Residual Sum of Squares (RSS) R-Squares (R^2) F-Test Log-likelihood DW no. of observations no. of parameters mean(LARHRV) var(LARHRV)		0.046874 0.021971717 0.845052 (22,10) = 2.479 [0.069]* 73.8644 2.27 33 23 0.0179587 0.00429698
AR 1-2 test: ARCH 1-1 test: Normality test: RESET test:		F(1,9) = 0.49614 [0.4990] F(1,8) = 0.015049 [0.9054] Chi^2(2) = 5.5887 [0.0612]* F(1,9) = 1.4891 [0.2534]

Δ – denotes changes in the variable; Levels of significance: * 1%; ** 5%; *10%**

Diagnostic tests performed on the model did not reveal any autocorrelation or heteroscedasticity. Although the test for normality is rejected at the 10% level, we can attribute this to some of the outliers identified in the data or the small sample. In time series econometrics, if the test for normality is rejected, but the model is free from autocorrelation, it is possible to use asymptotic theory to argue that the significance of the tests will be asymptotically valid. Furthermore, the normal test for functional form misspecification - the Ramsey-RESET test (Regression Specification Test) - confirms that model has been correctly specified. The value of R^2 suggests that 85% of the variations in maize production over the study period are explained by the variables in the model.

The results suggest that previous changes in acreage have an influence on current acreage for the first and second lags as well as the fourth lag. The negative coefficient suggests that farmers are increasing acreage for producing maize in response to reductions in acreage in the previous period. That is, reduced output in the previous period will result in increased output in the future. These results conform to the data used in the study which show that total land area under maize production in Kenya has been increasing over the last few years. The results can be explained by the fact that shortages in the past will induce farmers to produce more in the next period. This is especially so for farmers who sell their maize to the National Cereals and Produce Board (the largest buyer of maize in the country). In a year of depressed production, demand from NCPB will outstrip supply and this will persuade farmers to produce more in the following period. These results are similar to those obtained by Kutha (2007) where changes in tobacco acreage were significant with a negative coefficient.

A growing economy has a significant positive impact on maize production for the first three lags. This means that positive changes in GDP growth rate in the previous period lead to increased maize production. A 1% increase in GDP growth rate leads to an increase of up to 0.14% in maize production. The implication here is that farmers are encouraged by a growing economy, possibly because this also means a good market for their produce where maize will fetch high prices. A study by Armstrong (2007) considered the effect of GDP growth on maize production. His results indicated a positive but insignificant relationship.

Producer prices were found to be significant determinants of maize production in this study for second to the fourth lags. Furthermore, the variable has a negative sign of the coefficient implies that farmers would increase maize production in response to reduction in prices in the previous period. This result corresponds to the theory generally known as a 'perverse supply' response which postulates that a price rise may actually induce farmers to supply less output. The perverse supply response crucially depends upon the assumption of a unit elasticity of the demand for money income so that when price falls by a certain proportion, farmers raise the marketed output by the same proportion to retain the same amount of money income. Hence, as price falls, marketed output rises, marketed output being defined as the amount of production net of consumption by the farmers (Ghatak and Ingersent, 1984). In the case of Kenya, the results are surprising but could be explained by the fact that most maize producers being small scale farmers target their production such us to meet their consumption needs and to achieve a certain income level by selling excess produce once consumption needs are met. As such, if price falls, their income levels fall and there is need for increased production to meet this income shortfall. Results from other countries have had mixed results. While Mazivila (2002) found that Mozambican maize farmers did not respond to price incentives, the studies by Alemu *et. al* (2003) and Kutha (2007) found a positive relationship between own price and output with the latter having the first and second lags of tobacco price influencing acreage.

Changes in yield in the previous period were found to be significant for the second and third lags with a negative coefficient. A 1% decrease in prior period yield leads to a 0.2% increase in maize production. This means that poor yield in past periods will encourage farmers to produce more in the next period. This result is consistent with the findings on the acreage variable and underscores the importance of maize as a staple food crop in Kenya since farmers will always try to increase future production. A positive but insignificant relationship was also found by Kutha (2007) in the case of tobacco yield in response to acreage in Malawi.

One of the empirical questions in the study was to find out whether seed quality before and after liberalization had an influence on maize production. The econometric results point to a reasonably strong association between seed quality and maize production with the coefficient being significant at the 10% level. This result indicates that variations in seed quality following liberalization have negatively affected maize production. With different vendors now responsible for selling seeds, it is possible that there could be fake seeds in the market and that some of these are being purchased by farmers.

The results also show that the dummy variable for drought is significant at the 10% level and has the expected negative coefficient. This result differs though with those from the Mazivila (2002) study which found that variation in natural rainfall were not significant. The study by Odhiambo *et al* (2004) however found that rainfall was an important determine of agricultural productivity in Kenya. The variable was significant and had a positive sign thereby confirming that variations in weather patterns affect agricultural performance.

The 1994 dummy variable is significant at the 10% level. This probably due to the fact that the effects of liberalization has been positive on maize production. The dummy variables for 1964, 1965 and 1967 are not significant in the short run. Similarly, the 1993 and 2000 dummy variables were also found to be insignificant. The results also show that maize production is not responsive to changes in situations of civil unrest. The only possible explanation could be that the areas that have recently been affected by civil unrest are not the high maize producing areas. Similarly, civil unrest mostly affects the urban areas and as such the maize producing rural areas would not be adversely affected by civil unrest. Nevertheless, because the relationships are insignificant, we do not attempt to provide further insight into this outcome.

Of the three error correction terms in the equation, the first term (ECM_{-1}) and the second term (ECM_{-2}) are significant but it is only the former that has the expected negative sign. The coefficient shows the speed of adjustment. The speed of adjustment to the long run equilibrium maize production is 11%. The results of the error correction model suggest that in the natural log of acreage equation, it would take approximately 9 years to go back to equilibrium after a shock to the system.

CHAPTER FIVE - CONCLUSION AND POLICY IMPLICATIONS

5.1 SUMMARY AND CONCLUSION

The study set out to identify and analyze the determinants of maize production in Kenya in the period 1963 – 2006. The study looked at both price and non-price factors influencing maize production including yield, macroeconomic environment, political environment, weather and seed quality. An error correction model was used to analyze the long-run and short-run effects of various factors determining maize production. Except for, civil unrest, all the other variables included in the model were found to be significant determinants of maize production in the long-run and short-run. GDP growth has a significant positive influence on maize production in the short run. Producer prices have a positive influence on maize production in the long run but the short run effect is negative. Acreage harvested in the previous period as well as yield were all found to negatively influence maize production in the short run. The study also found the effect of the 1967 Land Control Act to be positive. Also liberalization in 1994 is likely to have had a positive effect on maize production. Overall, the variables in the model explain 85% of the supply of maize over the study period in Kenya.

5.2 POLICY IMPLICATIONS

Many African countries including Kenya, are facing an imminent food crisis. Whereas at independence most of these economies were self-sufficient in food production, a combination of factors including rapid population growth, increasingly oil prices, adverse weather, poor macroeconomic and sectoral performance, and declining public investment in infrastructure have undermined the capacity of these economies to supply sufficient food from domestic sources. The ultimate effect of these is reflected in the decline in per capita food production, increased poverty and civil strife. Enhancing existing strategies to pursue sustainable maize production in Kenya and formulating new ones is therefore indispensable for enhancing food security, peace and health.

Findings of the study indicate that, in Kenya over the study period, maize production is responsive to both price and non-price factors. Nevertheless, given the negative influence of price in the short run, the study seems to suggest that producer prices alone are inadequate to influence maize production. A compatible and integrated policy regarding the provision of input subsidies, improved seed quality and enhanced support for the agricultural sector may be required to influence production. Therefore, the integration of a simultaneous producer price and input policy in relation to maize production is essential to ensure adequate supply in Kenya.

A stable macroeconomic environment is important for maize production as confirmed by the significant response to GDP. Adverse macroeconomic conditions can lead to stagnation and decline in maize production. Policies towards stabilizing the economy and ensuring growth are crucial if we are to ensure stable and adequate production of maize in Kenya. In this regard, the government needs to keep in check the population growth which increases demand on public expenditure for health, education and other necessities. This in turn causes a serious decline in public investment in farmer support services such as research, extension and credit. This can be done by aggressively implementing the family planning programme which seems to have slowed down in the last decade. Secondly, the government needs to revisit the successes in the agricultural sector between 1960 and 1985 and seek to replicate them. Much of this success can be attributed to political leadership that encouraged creation of an institutional framework and policy environment that supported and sustained maize productivity growth. This was done by engaging both public and private sector organizations resulting in achievement of national food policy objectives.

Drought has a significant negative effect on maize production. Persistent drought has resulted in major food shortages which compromise rural and urban welfare and threaten food security. But globally, weather patterns are changing and the effects of global warming are only likely to make the situation worse. With a huge amount of Kenya's agricultural activities pegged on rainfall, the country is likely to face dwindling output from rain-fed agriculture with the maize crop set to bear the brunt. There is therefore need for concerted efforts to develop highly drought resistant maize varieties. Similarly, strategies to recycle soil nutrients should be developed to address the issue of deteriorating soil fertility.

The study also suggests that poor seed quality may have found its way into the market and this has negatively affected maize production in the short run. The government therefore needs to step up monitoring of the activities of seed vendors and deal firmly with those found to be selling poor quality seeds. This goes hand in hand with the need for continued research to develop and adopt high-yielding maize varieties that can be adapted to a wide range of agro climatic conditions.

5.3 LIMITATIONS OF THE STUDY

This study focused on the maize supply response over the period 1963-2006. Data availability and reliability was a major limitation for the study. Lack of data availability resulted in collection of data from various sources. This may sometimes result in some inconsistencies given different data compilation techniques. Gaps in available data further resulted in the need to update the missing data from the various sources as well as the use of proxies rather than the most appropriate measure. For instance, the interest rate for loans advanced by the Agricultural Finance Corporation towards seasonal crops would have been the most appropriate measure for credit to the agricultural sector. However, due to several gaps in this data, the nominal lending rate was used as a proxy. For weather, a dummy variable for drought was used instead of the actual values for rainfall.

REFERENCES

Alemu Z. G., Oosthuizen K and Van Schalkwyk H. D., *Grain-Supply Response in Ethiopia: An Error-Correction Approach*, Agrekon, Vol 42, No 4 (December 2003)

Armstrong P., (2007), *The Effects of US and EU Agricultural Subsidies on Growth in SSA*

Askari, H. and J. T. Cummings, (1977), *Estimating Agricultural Supply Response with the Nerlove Model: A Survey*, International Economic Review, vol. 18, issue 2, pp. 257-92

Barrett C. B., (2004), *Review of 'Determinants of Technical Efficiency and Policy Implications in Traditional Agricultural Production: Empirical Study of Nigerian Food Crop Farmers'*

Braulke, M., (1982), *A Note on the Nerlove Model of Agricultural Supply Response*, International Economic Review, Vol. 23, No. 1, February 1982

Central Bureau of Statistics, (various issues) *Economic Survey.*

Central Bureau of Statistic, (various issues), *Statistical Abstract*

Coleman D., and T. Young, (1989), *Principles of Agricultural Economics: Markets and Prices in Less Developed Countries*, Cambridge University Press

Export Processing Zones Authority, (2005) *Grain Production in Kenya*

Ghatak S., and Ingersent K., (1984) *Agriculture and Economic Development*, The Johns Hopkins University Press, Baltimore, Maryland

Gujarati D. N., *Basic Econometrics*, Fourth Edition, McGraw Hill, USA.

Heath, J. R., (1987) *Constraints on Peasant Maize Production: A Case Study from Michoacan*, Mexican Stdies/Estudio Mexicanos, Vol. 3, No. 2, pp. 263-286.

Jayne T. S., R. J. Myers and J. K. Nyoro, (2005), *Effects of Government Maize Marketing and Trade Policies on Maize Market Prices in Kenya*, Tegemeo Working Paper 15.

Kabubo, J. W., (1991) *Factors Influencing the Supply of Wheat: Analysis for Kenya 1970-1989*, MA Thesis, University of Nairobi

Karanja, M. A., A. Kuyvenhoven and A. J. H. Moll, (2003), *Economic Reforms and Evolution of Producer Prices in Kenya: An ARCH-M Approach*, World Bank Report, Kenya Country Office

Karanja, D.D. 1996. *An Institutional and Economic Analysis of Maize Research in Kenya*. MSU International Development Working Paper. No. 57. East Lansing: Michigan State University

Kibaara, B. W., (2005) *Technical Efficiency in Kenya's Maize Production: An application of the Stochastic Frontier Approach*, MSc. Thesis, Colorado State University.

Kingori, C. W., (2005), *The Impact of Agricultural Trade Support in Developed Countries on Maize Prices in Kenya*, M.A. Research Paper, University of Nairobi.

Kutha, L. B., (2007) *Dynamics of Acreage and Producer Price: The Case of Tobacco in Malawi*, MSc Thesis, University of Malawi

Leaver R, (2004), *Measuring the Supply Response Function of Tobacco in Zimbabwe*, Agrekon, Vol. 43, No. 1

Maitha, J. K., (1969), *A Supply Function for Kenyan Coffee*, Eastern African Economic Review, I, pp 63-70

Mati, B. M., (2000), *The Influence of Climate Change on Maize Production in the Semi-humid-semi-arid Areas of Kenya*, Journal of Arid Environments, Vol. 46 No. 4, pp 333-344.

Mazivila, D., (2002), *Policy Modeling for Cereals in Mozambique: Maize Supply Response to Price Policy 1975-2000*, MSc Thesis, University of Zimbabwe

Metson, J. E., (1978) *Normative Supply Response in a Mixed Farming System: A Study of Dairying and Maize Production in Nandi District, Kenya*, Doctoral Thesis, University of East Anglia

Munyi, VV. (1999), *Supply Response of Maize in Kenya: A District Level Analysis*, MSc Thesis, University of Connecticut, Storrs, CT

Nicholson W., (2004), *Microeconomic Theory: Basic Principles and Extension, 9th Edition*, South-Western College Publishers

Nicholson W., (2002) *Microeconomic Theory*, Dryden Press.

Nyangito, H., (1997), *A Review of Policies on the Maize Sub-Sector in Kenya*, IPAR Discussion Paper Series.

Nyangito, H., (1998), *Towards Maize Security in Kenya: An Evaluation of the Self-sufficiency Strategy*, IPAR Discussion Paper Series.

Nyangito, H., and J. Okello, (1998), *Kenya's Agricultural Policy and Sector Performance: 1964 -1996*, IPAR Occasional Paper No. OP/04/98

Nyoro, J. K., (2002) *Kenya's Competitiveness in Domestic Maize Production: Implications For Food Security*, Tegemeo Working Paper No. 14

Nyoro, J. K., M. Wanzala and T. Awuor (2001), *Increasing Kenya's Agricultural Competitiveness: Farm Level Issues*, Tegemeo Working Paper 4.

Nyoro, J. K., L. Kirimi and T. S. Jayne (2004), *Competitiveness of Kenyan and Uganda Maize Production: Challenges for the Future*, Tegemeo Working Paper 10.

Odhiambo W., H. O. Nyangito, and J. Nzuma, (2004), *Sources and Determinants of Agricultural Growth and Productivity in Kenya*, KIPPRA Discussion Paper No. 34

Ongile, G. A., (1996), *Gender and Agricultural Supply Response to Structural Adjustment Programmes: A Case Study of Smallholder Tea Producers in Kericho, Kenya*

Simatele, M. C. H., (2006), *Food Production in Zambia: The Impact of Selected Structural Adjustment Policies,* African Economic Research Consortium, Research Paper No. 159.

Thomas R. (1997), *Modern Econometrics: An Introduction*, Harlow. Addison-Wesley, England

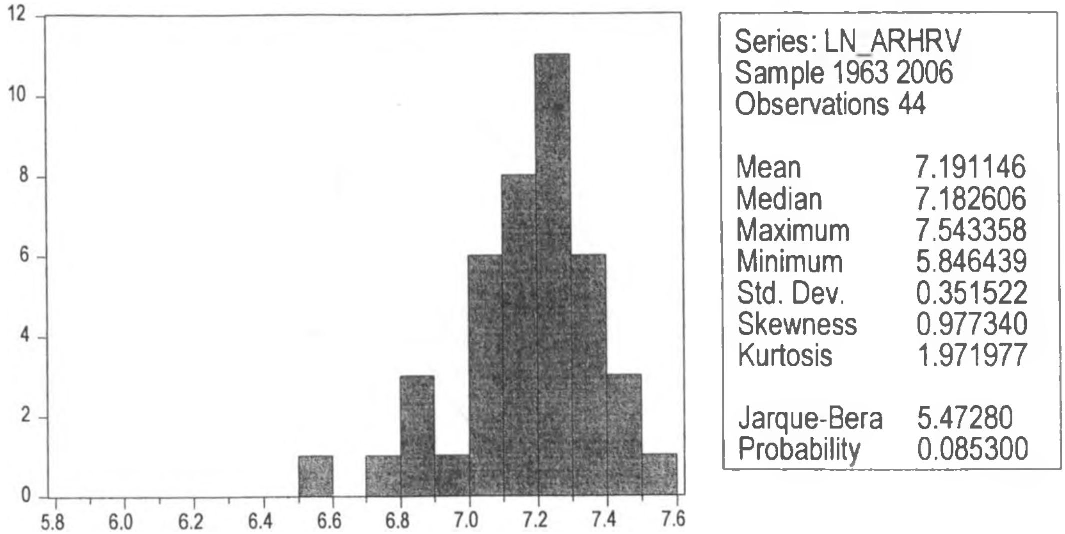
Timmer, C. P., W. P. Falcon and S. R. Pearson (1983), *Food Policy Analysis*, Johns Hopkins University Press

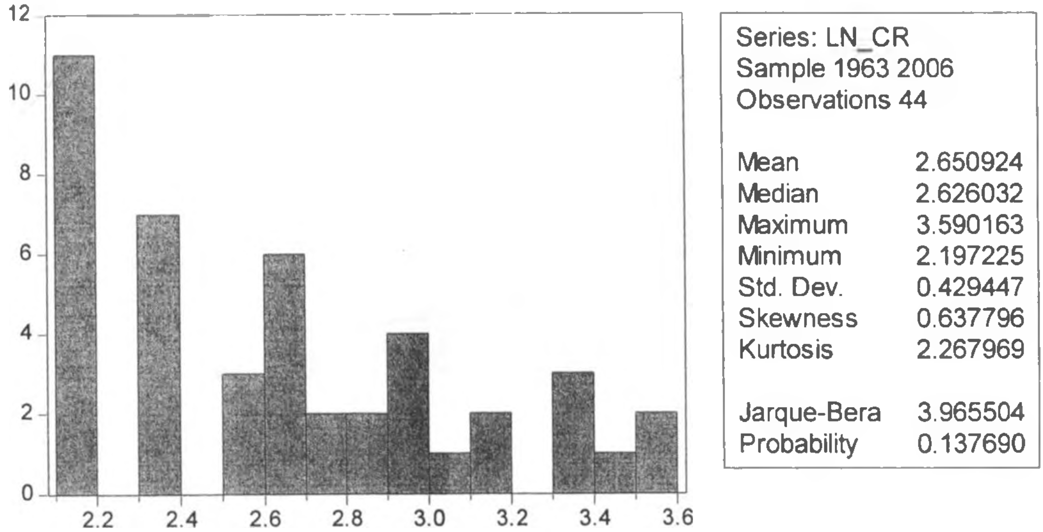
Tsakok, I., (1990) *Agricultural Price Policy: A Practioner's Guide to Partial Equilibrium Analysis,* Cornell University Press, Ithaca and London

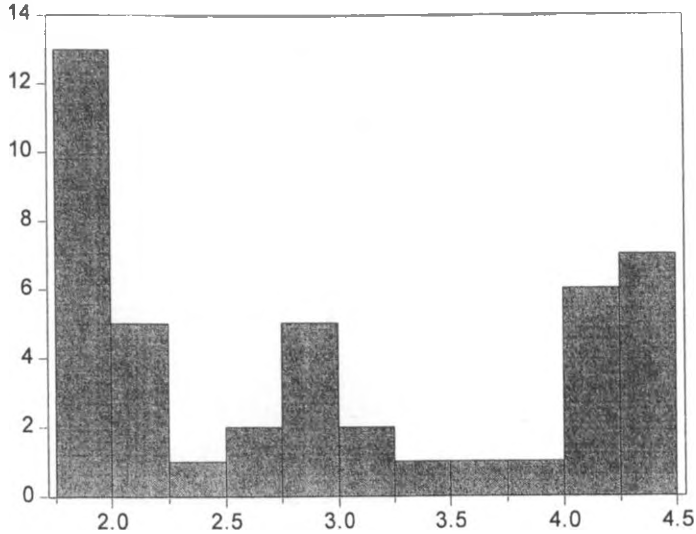
World Bank (1994), *Adjustment in Africa – Reforms, Results and the Road Ahead*, The World Bank.

APPENDICES

Appendix 1: Time Series Characteristics of the Variables

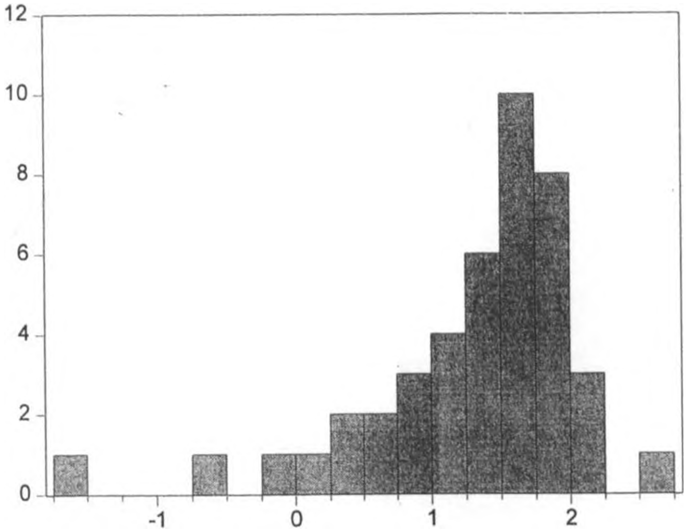






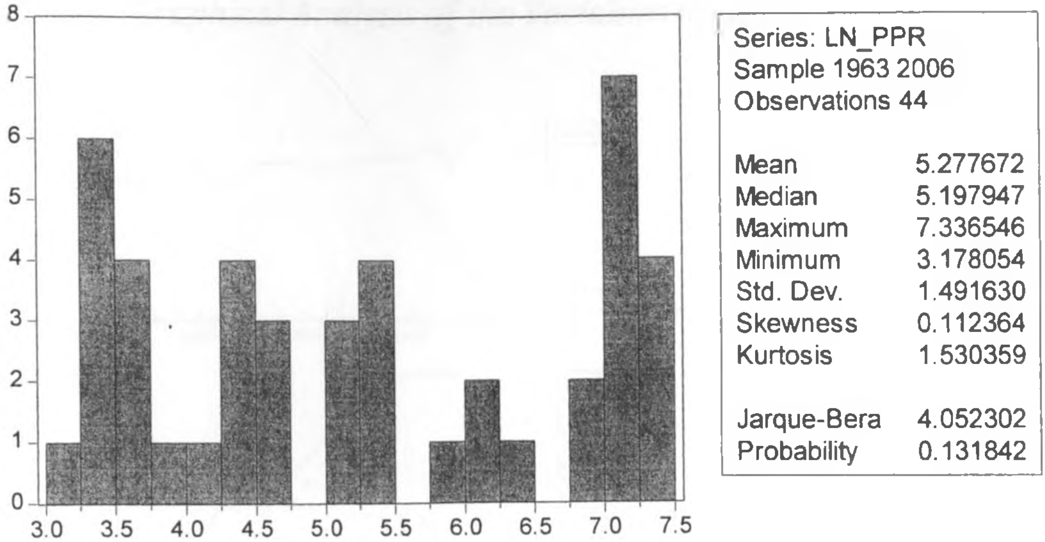
Series: LN_EXRATE
Sample 1963 2006
Observations 44

Mean	2.942478
Median	2.766914
Maximum	4.364372
Minimum	1.931521
Std. Dev.	0.969016
Skewness	0.363226
Kurtosis	1.463613
Jarque-Bera	5.295065
Probability	0.070826

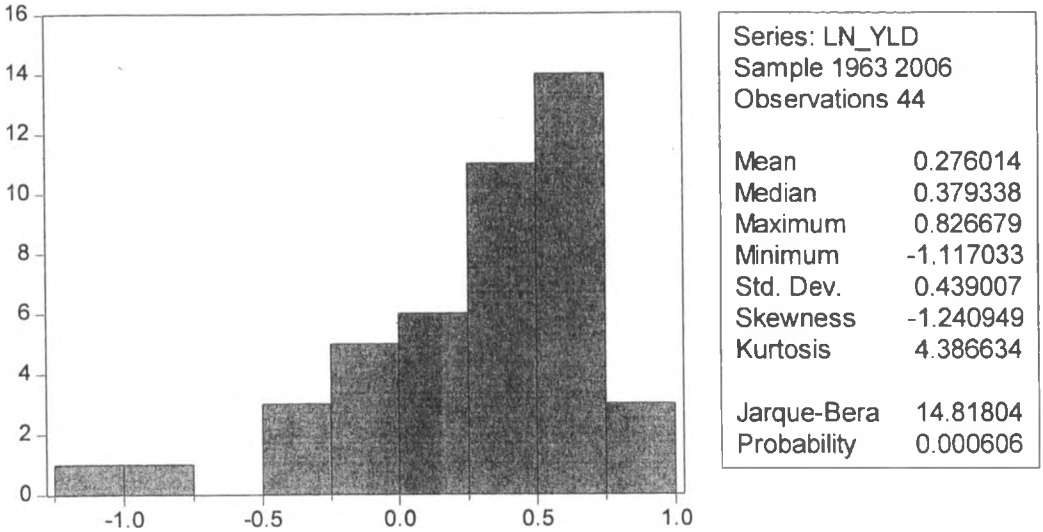


Series: LN_GDP
Sample 1963 2006
Observations 43

Mean	1.275238
Median	1.526056
Maximum	2.674149
Minimum	-1.609438
Std. Dev.	0.800461
Skewness	-1.522904
Kurtosis	5.879862
Jarque-Bera	31.48056
Probability	0.000000

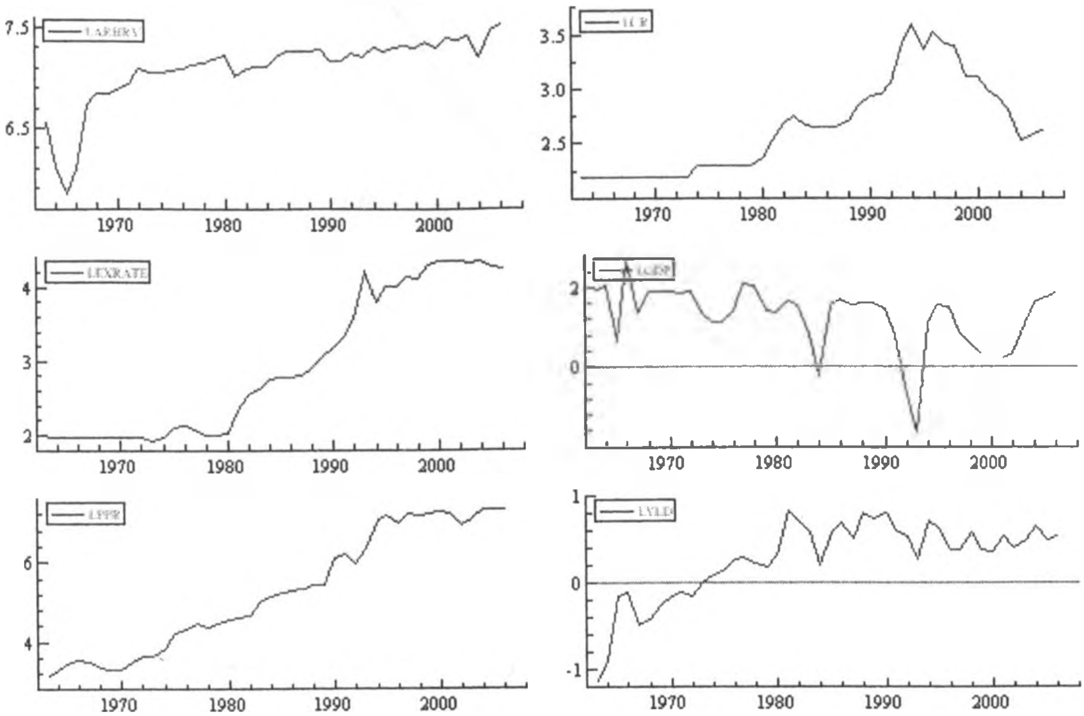


Series: LN_PPR
Sample 1963 2006
Observations 44
Mean 5.277672
Median 5.197947
Maximum 7.336546
Minimum 3.178054
Std. Dev. 1.491630
Skewness 0.112364
Kurtosis 1.530359
Jarque-Bera 4.052302
Probability 0.131842



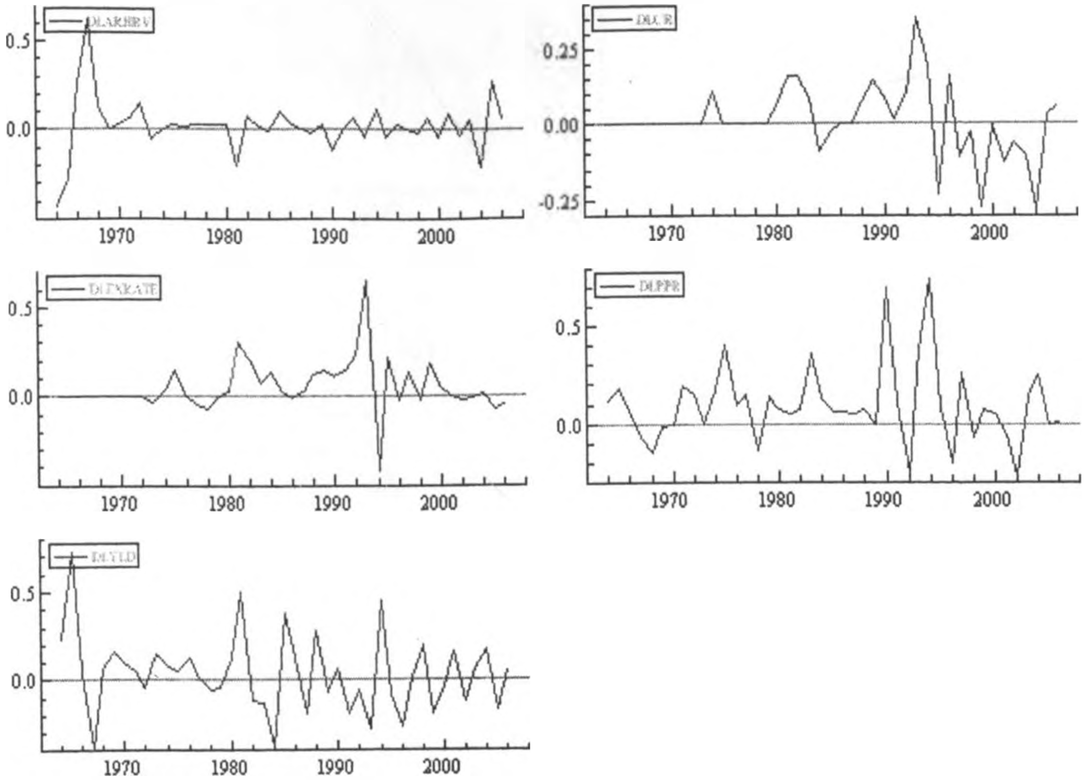
Series: LN_YLD
Sample 1963 2006
Observations 44
Mean 0.276014
Median 0.379338
Maximum 0.826679
Minimum -1.117033
Std. Dev. 0.439007
Skewness -1.240949
Kurtosis 4.386634
Jarque-Bera 14.81804
Probability 0.000606

Appendix 2: Graphical Analysis of the Variables in Levels



Note: ARHRV – Acreage planted; CR is credit; EXRATE is the exchange rate; GDP is the growth rate; TOUTPT is the total output; PPR is the producer price and YLD is the yield.

Appendix 3: Graphical Analysis of the Variables in their first difference



Appendix 4: Plot of Residuals