FACTORS INFLUENCING THE SUPPLY OF SUGAR: AN ANALYSIS FOR KENYA 1970-2003

BY

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DECLARATION

This research paper is my original work and has not been presented for a degree award in any other University.

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This paper has been submitted for examination with our approval as University Supervisors.

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Dedication

Dedicated to my late parents Mr. Jacob Gitahi Kinini
And Mrs. Tabitha Nyathoko Gitahi.

Acknowledgement

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List of Abbreviations

AFC	Agricultural Finance Corporation
COMESA	Common Market for Eastern and Southern Africa
CBS	Central Bureau of Statistics
ESAF	Enhanced Structural Adjustment Facility
ECM	Error Correction Model
ICO	International Sugar Organization
ICUMSA	International Commission for Uniform Methods of Sugar Analysis
IRF	Impulse Response Function
KBS	Kenya Bureau of Standards
KSA	Kenya Sugar Authority
KESREF	Kenya Sugar Research Foundation
KMD	Kenya Meteorological Department
SAPs	Structural Adjustment Programme
VECM	Vector Error Correction Model

Abstract

Domestic demand for sugar in Kenya has continued to outstrip domestic production levels over the last three decades. Over the last ten years the country has registered an average annual deficit in sugar production of one ninety thousand metric tones. This gap between domestic production and domestic demand has to be met through importation.

The main objective of this study was to investigate the factors that influence supply of sugar in Kenya with the aim of proposing policy measures to improve production.

The study found out that producer price, area under sugarcane and average annual rainfall and structural policies implementation phase are significant factors influencing sugar production
The broad results indicate that improving producer price of sugarcane, acreage under sugarcane and availability of water (e g through irrigation) would improve the quantity of sugarcane supplied
Results of the study also indicate that implementation of structural adjustment policies adversely affects sugarcane production.

Previous periods yields of sugarcane and the periods before introduction of SAPs and SAPs policy formulation stage were found not to influence sugarcane production. This may be attributed to the fact that sugarcane is perishable industrial crop.

Policies recommended from the findings of the study include that producer prices be made more favourable to sugarcane farmers, extensive methods of farming be enhanced and irrigation methods be employed.

The short-run and long-run elasticities of output to various variables are equal implying that policy impact on sugarcane production will persist into the future and have a permanent impact.

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CHAPTER 1

1.0 INTRODUCTION

1.1. Background to Study

Sugarcane (Saccharum Officinarum) grows in the equatorial region and the tropics and warm temperate zones between 35^0 North and 35^0 South. On average sugarcane requires a minimum rainfall of 1000 mm well distributed throughout the year, but optimum rainfall requirement is 1500 mm if satisfactory growth and yield are to be realized. Altitude with its moderating effect on temperature has a significant impact upon duration of sugarcane maturity and subsequent length of the crop cycle (Odada & Awiti, et al 1986). Sugarcane is only but one source of sugar consumed in the world, beet, produced in the temperate zones, has been for a long time a significant source of sugar. There has also been a significant move in the production of sugar from corn.

The sugarcane industry is one of the oldest food processing industries in the world. Writers on ancient civilizations in Egypt and India reckon that sugar extraction from sugarcane was part and parcel of these civilizations. As civilization spread to Western Europe, sugar extraction from sugarcane became a significant process of the transfer of technology in those medieval days. The Industrial Revolution in the 17^{th} century in Europe gave the industry a big boost to the extent that sugar became "white gold" because of its profitability. The sugar industry was the cornerstone of the "triangular trade" which began with tradables from Europe being taken to Africa to be bartered for slaves. The slaves were exchanged in the West Indies for sugar which was then shipped to Europe.

In 1964, contributions of developed and developing countries to world supply of sugar were more or less equal. By 1982, the developing countries share in total world sugar production had increased to 60%. The rate of increase in sugar production has been higher in developing countries.

The following table shows world sugar production and consumption for the period 1964 to 1985

Table 1.1 World Sugar Production and Consumption (1964-1985) (million tonnes)

	1964-1966	1968-1971	1974-1976	1979-1981	1982	1985
Production						
Developed Countries	31.7	32.7	33.6	37.1	38.6	39.7
Developing Countries	31.5	38.0	35.9	51.3	62.8	60.2
Total	**63.2**	**70.7**	**69.5**	**88.4**	**101.4**	**99.9**
Consumption						
Developed Countries	39.6	42.0	44.3	44.0	44.0	45.0
Developing Countries	23.6	28.6	34.9	44.0	48.0	53.2
Total	**63.2**	**70.6**	**79.2**	**88.0**	**92.0**	**98.2**

Source: World Food Prospectus, various

The highest level of world sugar production was attained in 1982 when production reached on all time pick of 101.4 million tonnes. By 1964, developed countries had a higher rate of sugar consumption than developing countries.

The major world producers of sugar are: India, Brazil and Cuba while in Africa, the leading sugar producing countries are South Africa, Egypt, Mauritius, Swaziland and Zimbabwe in that order (International Sugar Organization, 2002). By international standards, Kenya is considered a marginal producer of sugar.

1.2 Role of Agriculture in the Economy

Agriculture accounts for almost 25% of GDP (Statistical Abstract – 2003).

Sessional Paper No.1 of 1986 spelt out the goals of the agricultural sector to the year 2000 Self-sufficiency in foodstuffs and food security is stressed as the long-run goal In the short-run, appropriate policies need to be formulated to revitalize the sugar sub-sector and enable it attain long-run goals. Contrary to these intended goals as spelt out in Sessional Paper no. 1 of 1986, the trend depicted by the table 1.5 shows that demand continues to outstrip domestic supply and that the shortfall is expanding. This means that both short-run and long-run sugar policies need to be amended to reverse the trend.

1.3 Kenya's Economic Structure

The macro-economic performance of the Kenyan economy since independence can be assessed in the context of external shocks and internal challenges that the economy has had to adjust to. Four phases are identifiable: a rapid economic growth phase over the period 1964-73, an era of external shocks over 1974-79 dominated by oil shocks and coffee boom; a period of stabilization and structural adjustment in the 1980s and an era of liberalization and declining donor inflows from1990s to date. The overall effects of changing circumstances have been a declining trend as shown in table 1.2.

Kenya's Economic structure comprises of monetary and non-monetary sectors. In the monetary sector, agriculture continues to be the dominant sector followed by government services and then manufacturing.

Kuznets (1966) postulated that for a country to industrialize, the contribution of agricultural sector to GDP tend decline and contribution of industrial sector (manufacturing) tend increase. From the table 1.2 it is clear that growth rates of GDP in both agriculture and manufacturing have been declining over time. This means that the decline in the agriculture is not being compensated by growth in the industrial sector. There is no evidence of structural shift from agriculture to industrial sector. Therefore the decline in growth in the agricultural sector is not due to the process of industrialization. Manufacturing registered a marginal growth in contribution to GDP from 10.6 % in the period 1964-73 to 13.3 % for the period 1996-2000.

GDP growth rate is projected to improve to 4 per cent in the period 2001-2008(Development Plan, 2002).

Table 1.2 Annual Growth Rate of Real GDP (%)

Sector	1964-73	1974-79	1980-89	1990-95	1996-2000	2001-08*
Agriculture	4.6	3.9	3.3	0.4	1.1	3.3
Manufacturing	9.1	10.0	4.8	3.0	1.3	3.3
GDP	6.6	5.2	4.1	2.5	2.0	4.0

Source: National Development Plan, Statistical Abstract, various

Table 1.3 Distribution of GDP by sector (%)

Sector	1964-73	1974-79	1980-89	1990-95	1996-2000	2001-2008*
Agriculture	36.6	33.2	29.8	26.2	24.5	22.4
Manufacturing	10.6	11.8	12.8	13.6	13.3	12.2

Source: National Development Plan, Statistical Abstract, various

* projected

In 2002-2008 National Development Plan, the government re-asserted its aim of revitalizing the sugar industry to ensure adequate supplies for local consumption.

In the decade 1963-73, Kenya's economy grew at high rates, with GDP expanding by 6.6 per cent per annum. This was due to increased agricultural output; expansion of manufacturing sector supported by adoption of import substitution strategies; rising domestic demand, expansion of the regional markets and substantial inflows of foreign aid. Fluctuating world prices of agricultural products and the oil crisis reversed the impressive economic performance experienced in the first decade. The first oil crisis of 1973 brought an abrupt decline in economic growth rate. The growth rate declined to below 4 per cent except for 1976/77 when the unexpected coffee boom saw the GDP grow at 8.2 in 1977. The collapse of the East African Community (EAC) in 1977 and the second oil crisis of 1979 contributed to further deceleration in economic performance.

Unfavourable weather conditions experienced in the early 1980s, world recession and the international debt crisis worsened the domestic economic situation. The 1980s was also characterized with misaligned real exchange rates, fixed exchange rate regime as well as poor commodity pricing which all acted to undermine macroeconomic stability. To address the macroeconomic instability the government introduced liberalization and deregulation of trade and exchange rate regimes, public and financial sector reforms through the SAPs programme.Table1.4 summarizes the SAPs programme process as implemented in the agricultural sector.

In 1980 Kenya formally adopted the Structural Adjustment Programme (SAPs) which was being advocated by World Bank and IMF and was aimed at achieving structural changes and attain high levels of economic development. Between 1980 and 1985 the reform was mainly in policy matters.

In the second half of 1980s, there was gradual actual implementation of policies. The programme was characterized with liberalization of trade and prices including agricultural prices and foreign exchange decontrols. The SAPS meant that from mid 1980s, Kenya experienced changes affecting all the sectors of the economy. The sugar cane industry was liberalized in that period and there was free trade in sugar.

Before mid 1980s, the government controlled the sugar industry. The government was controlling the supply of sugar, pricing and marketing as well industry's processing.

Table 1.4 SAPS implementation process

TYPE OF POLICY INTRUMENTS	MACROECONOMIC INTRUMENTS	AGRICULTURAL SECTOR INTRUMENTS
Pricing policy	Exchange rate Wage rate Interest rates	Output prices (Administered), Wage rate Irrigation charges Agricultural interest rates
Fiscal policy	Subsidies, Tax rates, Public investment	Subsidies, Tax rates Public investment
Monetary policy	Money supply, target interest rate, Credit allocation	Agricultural credit targets Agricultural interest rate
Trade policy	Tariffs and quotas Export subsidies	Tariffs and quotas Export subsidies
Institutional reforms	Monetary management rules, Management of parastatals, Divestiture in public enterprises	Marketing Boards reforms, Reduction of intermediation costs in agricultural banks, Improved agricultural research
Land policy	Cadastral survey plans Land taxes/levies Zoning	Land taxes/levies, Land Titling, Sale Policy of Public land Consolidation of scattered parcels

Source: Food Security, Food aid and Structural Adjustment in Agriculture, pg. 9

In introducing the SAPs programme, the expectation was that agricultural sector would respond to SAPs policy changes through increased agricultural supply of exports, help restore balance of trade and assist in moderating domestic inflation and contribute to the process of internal adjustment through increased food production.

The SAPs reform programme has been criticized on the grounds that a market-based approach is inappropriate due to market imperfections in many sub-Saharan African countries (Obidegwu, 1990).

In Kenya, a study by Mwega (1995) concluded that trade liberalization, including the agricultural sector, arising from SAPs does not seem to be positively correlated with productivity growth but is positively correlated with output and employment growth in the manufacturing sector.

In the 1990s and early 2000s, poor economic performance can be attributed to declining donor funds; poor weather and infrastructure; insecurity; declining tourism activities and poor performance of the manufacturing sector. Overall GDP growth declined further to 2.5 per cent between 1990 and 1995 to 2 per cent between 19996 and 2000. The decline in economic performance was apparent in all the sectors of the economy.

Liberalization of the economy introduced major changes in marketing and pricing of sugar. Before introduction of SAPs, importation of sugar was controlled by the government by licensing particular importers/ agents and allocating import quotas through Kenya Sugar Authority. Uncontrolled imports of white sugar which is more refined than locally produced sugar found its way to the domestic market. Its importation is done by private firms and individuals. The SAPs programme therefore introduced competition between local sugar firms and sugar importers. Tariff on sugar imports is aimed at bringing prices for imported sugar to a level which represent reasonable remuneration for the efficient producer at an acceptable level of risk. This is because the price at which sugar can be imported from the world market at any one time bears little or no relation to the cost of producing that sugar. A possible reason of low prices of imported sugar is application of agricultural subsidy policies in source countries and more efficient production methods. A sugar importing country that fully exposes its domestic industry to world prices faces negative impacts to development of sugar-based industries.

1.2 Sugar Production in Kenya

Sugarcane production in Kenya on a commercial basis was started in 1922 when the Miwani Sugar Mills Limited established a medium-scale sugar mill at Miwani in Kisumu District of Nyanza Province. A second sugar company was established in 1927 by Associated Sugar Company at Ramisi in Kwale District of Coast Province. These sugar mills were owned by and managed almost exclusively by Asians. African farmers started playing a major role in the production of sugarcane when two additional sugar mills were established by Kenyan Government in Kisumu District. These were the African Sugar Company Limited at Muhoroni (1966) and Chemilil Sugar Company Limited (1967). Establishment of the two sugar schemes saw the beginning of direct participation of the Kenya Government in the sugar industry in the form of ownership.

A fifth sugar mill was established by the Kenya Government at Mumias in Kakamega District of Western Province in 1973. This was followed by a sixth sugar mill at Nzoia in Bungoma district of Western Province. A seventh sugar (Sony) mill was established in 1979 at Awendo in South Nyanza Province. The establishment of these large-scale sugar schemes led to a significant increase in domestic supply of sugar in Kenya since the mid 1960s, and led the country to self sufficiency in sugar in 1979 (see table 1.7) below. In 1994, West Kenya Sugar Company was established in Western Province. Miwani Sugar Mill was closed down indefinitely in February 2002 while Ramisi was closed down in 1988.

1.3 ORGANISATION STRUCTURE OF KENYA'S SUGAR INDUSTRY

In Kenya cane is grown either in the nucleus estates, by outgrowers or contracted farmers. The nucleus estates (Plantations) are large parcels of land owned by the factory establishment. The nucleus estates are established to provide buffer against risk of inadequate cane supplies from out growers, provide sugar companies with a base for scientific research and cane husbandry and provide land facilities for the introduction of new sugar cane varieties

The out growers can be divided into four district categories: large scale farms, small-scale farms, cooperatives and settlement schemes. The large-scale farmers are concentrated in the Nyanza Sugar Belt where they deliver cane to Chemilil, Muhoroni and Miwani Sugar factories. Cooperative sugarcane farming is least developed and is found in Nyanza Sugar Belt (mainly

Chemilil and Miwani Sugar Schemes). Settlement Schemes Sugarcane farmers deliver cane to Muhoroni and Chemilil Sugar factories. Area under cane for outgrowers, nucleus estates and contract farmers and the average cane yield for the various factories for 2003 is shown table 1.5.

Table 1.5 Area Under Sugarcane By Factory And Average Cane Yield-2003

Factory	Area Under Cane (hectares)			Average Cane Yield (Tonnes/ha)
	Outgrowers	Nucleus	Contract Farmers	
Chemilil	9256	2017	-	63.38
Muhoroni	8305	1345	-	57.10
Mumias	45031	3432	-	75.93
Nzoia	13160	3333	-	74.75
Sony	10807	2270	-	77.66
West Kenya	6240	1850	-	69.25
Miwani*	6300	–	–	–
Ramisi**	–	–	–	–

Source: Kenya Sugar Board, 2004

* closed down at beginning of 2002

** closed down in 1988

Mumias Sugar factory has the greatest area under cane for both the outgrowers and nucleus estate while Miwani had the smallest. Average cane yield (i.e. no. of tonnes of processed sugar per hectare) is highest in Sony Sugar mill and smallest in Mumias sugar mill. The average cane yield may be affected by cane variety and relative efficiency of factories in sugar processing. Table 1.6 Summaries information on the six major sugar factories which are operational.

Table 1.6 Sugar Factories In Kenya- Annual Rated Milling Capacity (At Inception)

Factory	Year of Establishment	Rated milling capacity of sugar(1000'Metric tonnes)
Muhoroni	1966	60,000
Chemelil	1967	55,000
Mumias	1973	180,000
Nzoia	1978	60,000
Sony	1979	60,000
West Kenya	1994	50,000

Source: Kenya Sugar Board, 2004

The rated milling capacity is number of tonnes of sugar the factory is capable of processing per year, assuming adequate cane supply and allowance for servicing of machines. The figures reflected above show the rated capacity of the factories at the time of inception and are expected to decrease over time due to depreciation or some machines being rendered obsolete due to changes in technology. The factories operate with excess capacity due to inadequate supply of cane. Seasonal fluctuations of cane supply may also force the factories to operate at sub-optimal capacity. Mumias factory has the highest milling capacity while West Kenya which was established in 1994 had the lowest.

1.3.1 Performance of the sugar industry

The performance of the agricultural sector in general in the decade 1964-1974 was impressive. It's contribution to GDP in that period was 36.6 per cent but declined to 26.2 per cent in 1990-1995 and 24.5 percent in the period 1996-2000 and is projected to contribute to GDP at an average share of 22.4 per cent over the period 2001-2008(see table 1.3).

The performance of the sugar sub-sector shows that demand continues to outstrip supply (production) which means that the deficit must be met through sugar importation.

The following table depicts sugar production and consumption Kenya for the periods 1974-1984 and 1994-2003.

The table shows there was declining deficit in the period 1974-1978 and a movement towards self- sufficiency reflected by the surplus between 1979-1982. The trend was reversed in 1983 and from 1994 there was a large deficit in sugar supply.

Consumption in general depicts an increasing trend while production depicts a mixed trend and increased between 1994 and 1999, then registered huge decline in 2000-2001 with improvements in production in 2002-2003. Despite mixed performance in the production, domestic production was less than domestic demand in the entire period 1994-2003.

Table 1.7 Sugar Supply And Demand In Kenya: (000' Metric Tones) 1974-84; 1994-2003

Year	Production	Consumption	Deficit/Surplus
1974	163	224	-61
1975	180	203	-23
1976	170	195	-25
1977	185	200	-15
1978	238	260	-22
1979	296	253	43
1980	383	296	87
1981	368	367	1
1982	353	348	5
1983	325	333	-8
1984	371	380	-9
1994	387.5	566.2	-178.7
1995	388.6	563.5	-174.9
1996	389.0	570.0	-181.0
1997	401.6	580.6	-179.0
1998	449.1	587.2	-138.1
1999	470.7	609.4	-138.7
2000	401.9	631.2	-229.3
2001	377.4	644.5	-267.1
2002	494.2	680.5	-186.3
2003	448.5	691.6	-243.1

Source: Kenya Sugar Board, 2004

To fill the gap between domestic production and consumption, the country is forced to import sugar. To reduce importation, the country has to increase domestically produced sugar to the level of consumption. The industry, however, is faced with a number of constraints and challenges that may hinder realization of full potential. Decline in sugar production may be due to failure by the farmers to supply cane to factories because of reduced cane producer prices, unfavourable weather conditions, and increased imports (Economic Survey 2004). However only a comprehensive empirical study can investigate the underlying factors that have resulted in underproduction of sugarcane which has been unable to meet domestic demand over the years.

1.3.2 Sugar Cane Production

Production of sugarcane involves a number of mechanical operations right from the beginning until the crop is established, mature and harvested. In the initial stage, mechanical operations aimed at preparing suitable seed bed for cane planting are carried out. Where land is virgin, capital investment in bush clearing, de-stumping and land formation (leveling and grading) needs to be undertaken.

The soil is opened up by one round of deep ploughing and two rounds of light ploughing. Harrowing is then done to ensure a suitable soil tilth. After harrowing, sugarcane field is furrowed to make appropriate beds for seed cane. Sugarcane is a semi-permanent crop which is normally harvested at least three times before uprooting to plant a new sugarcane crop. The first sugarcane crop is known as "plant crop". The subsequent crops, before uprooting are known respectively as the "first ratoon" and "second ratoon" crops. While the plant crop normally matures in 22-24 months, the ratoon crops mature in 18-24 months. A complete sugarcane crop cycle thus takes about five years from the establishment of a plant crop to the harvest of a second ratoon crop.

Apart from geo-physical and climatic factors, sugarcane yields depend upon the qualities of initial land preparation, the seed cane and crop maintenance after establishment. Various varieties of sugarcane have different yields. However data on the various yields is not obtainable from factories as they pay a uniform price for cane delivered, irrespective of cane variety.

Because sugarcane is a semi-permanent crop it is important to plant appropriate seed cane varieties which should come from nurseries which had been established from heat-treated sugarcane as a control measure against ratoon stunting disease. However, a number of sugar companies supply their outgrowers with ordinary cane for planting due to scarcities of such nurseries.

Sugar cane requires nitrogenous, potassium or phosphate fertilizers and lime. For the small-scale farmer, the main agents who distribute these inputs are the sugar companies.

The common practice is to cut seed cane into three-node pieces known as "setts". These are then planted end to end in the furrow-beds and buried with soil. The most suitable time for planting is during rainy season from March to May and from September to November.

For good yields, sugarcane should be kept weed-free throughout its complete cycle. Hand weeding is widely adopted in all the sugar schemes except in Chemelil and Muhoroni where combination of hand weeding and chemical weed control are used.

Cane is harvested when it is considered mature and millable. In all the sugar schemes in Kenya, cane is cut by hand labour. In some schemes, mainly in Nyanza Sugar Belt, cane is burnt before harvesting to make the operation less cumbersome in both nucleus estates and out growers schemes.

The harvested cane is then loaded onto tractors or lorries and delivered to sugar companies. Although the sugar companies own most of transport facilities, a large number of private contractors and individuals have been attracted to this lucrative business. Cane arrives at the factory gates where the carriers are weighed together with the cane on arrival and re-weighed after they have been unloaded to determine quantity of cane delivered. At this stage the cane begins the manufacturing process which is described below.

1.3.3 Sugar Milling Process

Sugar cane processing to produce refined sugar is a capital-intensive process. Alternative use of sugar cane (e.g. in the brewing of local liquors) is prohibited by law, and therefore household consumption is negligible. In this respect sugar cane farming differs with other food crops where peasant families consume substantial proportion of their food production. Therefore the total production by farmers is also the total marketed production. In case of sugar cane industry, production per given period can be regarded as supply per the same period as sugar cane cannot be stored for future marketing as it is a highly perishable good, even if farmers expect higher prices in the future.

There are a number of stages in the processing of sugar. After off-loading, it is conveyed to cutting stage for milling. At the milling stage, the mass passed on, crushed and squeezed to extract juice from cane. The juice is then separated from waste material – (bagasse). Bagasse which is the fibrous stem after extraction of juice is used as fuel for the boilers. This use of waste material as an input in the production process substantially reduce production costs.

The juice is then strained through screens and heated, limed and phosphated to prevent conversion of sucrose into simple sugars. This process known as "clarification of the juice" results in precipitation and separation of suspended matter and soluble non-sugars in the juice. The juice is then led to evaporators where further boiling takes place in low pressure to remove impurities while darkening or browning due to burning is avoided.

The next process is crystallization where the thick syrup obtained from evaporators is fed to vacuum pans where the sugar saturated mixture of molasses and sucrose forms the massecuite. The massecuite is then purged into automatic centrifugal with a modicum of washing which separates the sugar crystals from molasses. The sugar crystals are then dried and bagged in 100 kg bags ready for distribution.

The bulk of the sugar produced in Kenya is known as mill-white sugar. It has a brownish colour due to incomplete removal of molasses coating. The extent of brownness varies with factory to factory, depending on the extent of processing method and the weather conditions prevailing at the time cane is harvested.

The Kenya government has put a minimum quality standards as regards colour and content of impurities in sugar in line with requirements of International Sugar Organization (ISO). This standard is based on International Commission for Uniform Methods of Sugar Analysis (ICUMSA) unit. The Kenya Bureau of Standards regulates the quality of domestic sugar.

1.3.4 Pricing and Distribution

Sugar factories usually do delivery of sugar cane from the farms to sugar factories. The prices that are charged for farm level mechanical services are set out by Kenya Sugar Board in terms of amount per hectare or per hour specified capacities of the equipment used.
As with many agricultural crops, the short-run supply of sugar cane is fixed as farmers will not be able to respond immediately to changes in producer prices. As with other agricultural commodities, there is a time lag between which supply can respond to changes in various explanatory variables. The adjustment process between production and various factors depend on technology being employed by the farmers(Odada, 1986).

Sugar cane farmers sell their produce to particular factories as they are controlled by the zoning system. Because of the single buyer in a particular region, the sugar factory is faced with an upward-sloping supply curve, which shows the quantity of sugar cane supplied to it by the farmers at different producer prices it pays to the farmers, subject to a reserve price that is expected to meet the production costs of a unit of sugar cane delivered to it by the farmer. The supply of sugar cane that farmers can supply to sugar industries is constrained by other factors apart from producer prices like cane variety, soil type, farming methods, weather, land and input prices. Reserve price is usually recommended price by farmers associations but sugar firms may choose not to go by it. The price paid to the farmer for his sugar cane is therefore not determined by the competitive markets. The sugar firms buy all the sugar cane delivered by farmers from a particular zone.

The price to farmers is determined by sugar factories that buy the sugar cane, add value by processing and then sell the finished product (refined sugar) to specified distributors to supply to retailers. However, because sugarcane is a perennial crop, substitutability with other food crops with shorter gestation period is difficult.

Sugarcane-processing industries, like other multinationals, are profit maximizing but are restrained by the fact that they buy sugar cane at a price that is equal or greater than the production cost of sugar cane to the farmer, otherwise the farmer would substitute sugar cane with other crops (e.g. maize, sorghum and millet) that grow in the same ecological zone as sugar cane and are apparent substitutes. However in the short-run, prices of these crops are unlikely to affect sugar supply as cane due to its semi-permanent nature.

No special financing of farmers is made by the sugar factories and the form of credit is offered is in seeds and transport. The factories then recover these costs from the proceeds of the farmers

Sugar cane market can therefore be regarded as a case of monopsonistic buyer (sugar-cane processing industries) operating under a restricted market due to zoning system, and the factories then market the refined sugar oligopolistically through appointed agents (distributors) The monopsonistic nature of sugar industries may result in consumer surplus in favour of sugar industries.

1.4 STATEMENT OF THE PROBLEM

Over the last two decades consumption of sugar in Kenya has continued to outstrip supply and therefore necessitating importation to fill the gap.

Sugar imports drain the country's foreign exchange as resources meant for investment in other sectors of the economy, including agricultural sector, are depleted

When a country relies on food imports, it creates a balance of payment crisis. Due to lack of foreign exchange, the country borrows both internally and externally to finance food imports, and this leaves little for investment by the government in the social services as a large proportion of revenue due to government is used in debt servicing. In developing countries, this may lead to debt crisis. Borrowing by government also crowds out private investment through high interest rates which increase cost of credit. The National Development Plan 2002-2008 spells out the government commitment in achieving self-sufficiency in basic foodstuffs in order to allow the nation to be fed without using scarce foreign exchange.

Given this gap between domestically supplied and consumed sugar and the possibility of BOP deficits and debt crisis, there is need to intensify domestic sugar supply to enable the country to be self reliant. The problem is on the supply side, which has to be raised to the level of domestic demand.

Sugar is a commodity that does not have close substitutes and demand for sugar is likely to increase with increase in population, as there is no likelihood of a decrease in consumption. More emphasis is therefore put on the supply side in order to save foreign exchange and the sugar cane farmer. The level of importation, given the decrease or marginal increases in domestic production, is likely to increase with increase in domestic demand arising from increase in population.

The study will try to identify the factors that influence supply of sugar and their relative importance.

1.5 Objective of Study

The objectives of the study are as follows:

(i) To identify the factors that influence sugar supply in Kenya.

(ii) To estimate the impact of these factors on sugar supply including the role of SAPs.

(iii) Estimate the short-run and long-run elasticities of supply of sugar.

(IV) To draw short-run and long-run policy recommendation from (i) and (ii) above

The production of sugar cane is likely to be affected by many factors such as producer price, hectarage under cultivation, SAPs, rainfall, marketing, sugar imports seed variety, soil type and other unpredictable factors.

1.6 Hypothesis

This study will attempt to test the following hypothesis. For each variable, the null hypothesis H_0 will be tested against the alternative hypothesis H_1.

1. H_0 : A positive relationship exists between supply of sugarcane and producer price to sugarcane farmers

   H_1: No relationship exists between the two.

2. H_0 : A positive relationship exists between supply of sugarcane and hectarage of sugarcane planted by farmers.

   H_1: No relationship exists between the two.

3. H_0: A positive relationship exists between supply of sugarcane and Mean annual rainfall in sugar growing zone

   H_1: No relationship exists between the two.

4. H_0: The phases of SAPs program are significantly different from no SAPs

   H_1: No significant differences exist.

5. H_0 : A positive relationship exists between supply of sugarcane in current period (t) and period (t-2).

   H_1: No relationship exists between the two.

Data on the appropriate variables to estimate regression coefficients will be collected, diagnostic tests conducted and the data analyzed. The effects of the qualitative variable (SAPs) will be captured through SAPs dummies. T-test will be carried out to assess the significance of coefficients and appropriate inferences made. Both short- and long-run elasticities will be derived from regression coefficients.

1.7 Significance of the Study

Sugar cane is an industrial crop that generate income to farmers and provide raw material to the sugar-based industries which are capable of providing gainful employment to a large proportion of Kenya's total agricultural labour force. The sugar cane crop enterprise will be able to fulfill these functions through multiplier effects only when sufficient incomes accrue to sugar cane farmers to enable then expand sugar cane production and leave them with subsistence for their immediate needs. There is therefore need to investigate the various factors that influence sugar supply in Kenya.

The study attempts to give policy guidelines that may be used by the authorities to increase domestic sugar production. The study will also provide useful guideline information to sugar management bodies on how the liberalization of the agricultural sector has affected the sugar industry in Kenya. Besides, it is hoped that this study will serve as a starting point to people wishing to pursue further studies in the sugar industry. It will also add value to the existing body of knowledge on the Kenyan sugar sector. Finally, the study will be of great importance to the sugar industry and policy makers.

In the last half of 1980s and early 1990s, Kenya experienced a lot of changes affecting all sectors of the economy. The sugar sector was liberalized in that period and there was free trade in sugar. Previous studies did not investigate the effects of SAPs policies on sugar sector, since all the industry's processes were being controlled by the government, from marketing of sugar cane, processing, pricing to distribution. According to COMESA Act of 2002, Kenya's quota of importation of sugar is 89,000 tonnes of common sugar and 111,000 tonnes of industrial sugar. Despite COMESA regulation imported sugar still finds its way into the country through the black market.

This study will add value to previous studies as it evaluates the temporal effects of SAPs policies.

This study is different from previous studies in that it will estimate the short-run and long -run elasticities of supply of sugar and aims at evaluating the supply of sugar in a liberalized economy. The study is also essentially differs from other studies in that it aims at carrying out structural analysis of the sugar supply in the study period.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Studies outside Kenya

Many previous studies of supply of agricultural commodities and covering a wide range of agricultural crops have been conducted in Kenya and other developing countries.

Krishna (1963) estimated supply elasticities for sugarcane, cotton, rice, millet, wheat and barley in the Punjab region and obtained short-run supply elasticities ranging from 0.08 for wheat to 0 72 for cotton and long-run elasticities ranging from 0.14 for wheat to 1.62 for cotton The study used Nerlovian Partial Adjustment Model.

Bond (1983) conducted a study to estimate aggregate agricultural response to real producer prices in sub-Saharan African countries, namely Ghana, Cote D'ivore, Kenya, Liberia, Madagascar, Senegal, Tanzania, Uganda and Burkina Faso. He developed his estimation equation by assuming that the actual changes in output (Q_t) in relation to previous existing level ($\bar{Q}_{t-1}$) is only some fraction of the change required to achieve equilibrium level ($\bar{Q}_t$).

$$Ln\ Q_t - Ln\ Q_{t-1} = \beta(Ln\ \bar{Q}_t - Ln\ Q_{t-1}) \quad \text{.......(i)}$$

He further postulated that equilibrium output ($\bar{Q}_t$) depend on the aggregate real producer price (P_t), a time trend (t) to take into account the effects of long-run equilibrium output, and a dummy variable (Z_t) to capture the influences of usual weather pattern.

The estimating equation was

$$Ln\ \bar{Q}_t = \beta_0 + \beta_1 LnP_t + \beta_2 LnQ_{t-1} + \beta_3 t + \beta_4 Z_t \quad \text{.......(ii)}$$

The regression analysis showed that the relative price coefficient were positive in all countries studied and that long-run price elasticity was greater than short-run elasticities in Ghana, Kenya, Liberia, Madagascar, Uganda and Burkina Faso. The study can be criticized on the ground that aggregate function for each country is obtained by adding across supply functions of individual crops, therefore it ignores the fact that individual crops react quite differently to changes in price.

Ramesh et al (1988) using time series data for the period 1960/61 to 1984/85 carried out a supply study aimed at examining the supply responsiveness of rice in India. His investigation reveals that there is a positive supply response to price incentive in developing countries. However, the magnitude varies according to nature of crop and between regions. He also separated area and yield responses models using Nerlovian lagged adjusted model. Yield was found to be responsive to prices, but area less so as cropping patterns tended to be more or less established. He concluded that the scope for increasing area under rice is limited unless a major irrigation is undertaken.

Binswanger, et al (1987) used a sample of 58 countries for the period 1969-1978 to analyze and determine the role of price and non-price factors on agricultural supply. The cross-country analysis, according to this study, is useful in understanding the implications of choice of technology on supply responses.

An interesting aspect of the study is the way variables are represented in the model, for instance, extension services are measured by the number of extension agent per capita of farm production, irrigation as a percent of agricultural land irrigated at least once during the year, research by number of years of training taken to convert workers into stock of scientists, the human capital by adult literacy and life expectancy.

The model was estimated by single equation technique but the large number of variables created the problem of multicollinearity. The results indicated that the variables as a group account for most variation in supply both within- country and between-country analysis. The results also show that the within country (time series) elasticity with respect to non-price is small around 0.1-0.2 (short-run elasticity) and that the cross-country elasticity is negative.

Ssmogerere (1990) investigated the effects of SAP policies on the supply condition of coffee in Uganda. The study used qualitative data due to lack of quantitative data. She used a supply model which assumed that acreage under coffee-yielding is fixed in the short-run, and might remain fixed even in the long-run if coffee is grown in densely populated areas where land is scarce. The study concentrated on the determinants of changes of output per acre on land productivity, to which variation of labour can be used in the short-run, and technological improvement, purchase input and tree planting can be applied in the long-run. The standard equation of the model is

$$Log(Q/H) = a_0 + a_1 \log P_t - a_2 \log P_t^{*} - a_3 \log Z_t + a_4 \log (l/r)$$

The study postulates that output per hectare (Q/H) is affected by the own producer price elasticity of supply, the price elasticity of substitute crop competing with coffee for the same productive resources P_t^{*}, stock of previous years output (Z_{t-1}) which vary with marketing efficiency, and land-rental ratio (L/r).

The study concluded that inefficient marketing system blocked the incentive as the farmers are paid late. An overall conclusion of the study is that whereas devaluation might be necessary to stimulate export by itself, it is not sufficient. An optimal pricing policy administered through the efficient marketing system, taxation reforms and exports diversification, appear equally necessary component of a successful adjustment programme.

This study can be criticized on the ground of using qualitative evidence instead of quantitative data. For this reason, it is impossible to compute the price elasticity of supply related to higher producer price.

2.2 Studies in Kenya

Maitha (1970) in studying the supply responses of Kenya coffee suggested that for a perennial crop like coffee, the appropriate dependent variable is productivity rather than acreage or new planting as has been in most studies. He concludes that farmers reaction to price changes will depend on the amount of suitable land available.

Maitha proposed that farmers can react to price incentives by improving their output in quality and quantity. Maitha used an aggregate production function of the CES type and a Fisher distributed lag to derive his productivity equation. Acreage productivity index was the dependent variable while lagged price (derived through Fisher distributed lagged method) and a time trend were his independent variable. The model was estimated by Ordinary Least Squares (OLS) method.

The result show that both the short-run and long-run elasticities from this equation were higher than the ones obtained by the same author when acreage was used as the dependent variable

Maitha (1974) studied maize and wheat production response with respect to price in Kenya. His study used the data on large farms for period 1954-1969. He adapted the Nerlovian model, in estimating the acreage of wheat and maize separately, with the difference that farmer price expectation was specified as a distributed by model with a known lag. Wheat and maize were treated as mutually competing crops. However, he used Ordinary Least Squares in estimating the final reduced form, where acreage under the crop in previous year, a lagged dependent variable appeared as explanatory variable. The results indicated that Kenya farmers do respond to price changes and that in general, the price elasticity for maize is greater as compared to wheat.

Available literature on Kenya sugar industry suggest that most researchers tend to focus their research efforts on broad agricultural system represented by sugar industry in Kenya. Ogendo and Obiero analyzed factors that influence location of sugar factories in East Africa and concluded that the government of the East African Countries played a significant role in the location of sugar factories.

Barclays (1977) studied the individual fate of a small part of population which was evicted from the Mumias Sugar Scheme in the process of land acquisition for the factory. He assessed private and social gains brought about by the sugar factory to ascertain its impact on the economy

Odhiambo (1978) described the production structure of Kenya's sugar industry and assessed the extent to which the production structure affects performance at the farm, factory and national levels. He concluded that shortages of cane supplies to the factories are the main cause of under utilization of factory capacities.

Wambia(1979) estimated the foreign exchange impact and internal rate of return of Mumias sugar factory and concluded that establishment of sugar factories is an effective way of generating and conserving foreign exchange.

Odada (1986) used Cobb-Douglas production function to derive the supply function (long-run) and related supply output to inputs of cane production by the formula:

$$Q_s = (A)^{\beta 1} \ (1/w)^{\beta 2} \ (\beta/I)^{\beta 3} \ (P)^{\beta 4}$$

Where

Q_s = Quantity supplied

A=technological parameter

I=cost of capital

W=wages in sugar industry

P= producer prices

β1, β2, β3, β4 are partial elasticities.

He estimated the cane supply structure in all of the four sugarcane growing zones and estimated the extent to which cane producers in the various zones respond to changes in cane price

A study by Odada (1986) estimated the supply of sugar in Kenya using Constant Elasticity of Substitution (CES) for the sugar growing zones. The study conclude that cane farmers were capable of adjusting the level of cane supplied to changes in cane price paid to farmers by sugar firms and that production in Kenya can be expanded sufficiently by increasing the relative profitability of sugar cane growing enterprise. This study was conducted before SAPs programme was fully operational and marketing and pricing of sugar was partially still under the control of the government.

Coughlin (1986) asserted that sugar industry has an inappropriate price structure, which rewards those not directly involved in sugar industry and recommended that the price structure be

overhauled to reward the farmers. This was an important recommendation considering it has always been Kenya government's aim to raise the standard of living of farmers through increased agricultural earnings (Sessional Paper No.10, 1965).
Mbogoh(1988) utilized distributed lag model to estimate the elasticity of cane supply and concludes that Kenya approach to self sufficiency in sugar supply has been rather low According to his projections, Kenya should have been self-sufficient in sugar production by 1983.

In other studies done in Kenya, various response function for wheat have been estimated for Kenya. A study by Kirori and Gitu (1991) estimated various supply response function at a national level. The estimated national short-run and long run price elasticities were 0.99 and 0.496 respectively. The gross price elasticity with respect to price of milk at national level was found to be –0.321. Other studies are those by Kabubo (1991) and Harsun et al (1992). All these studies indicated that farmers' responded to producer prices.

2.3 Overview of the Literature

The literature reviewed above is diverse and different approaches have been used to organize supply both in developed and developing countries. The factor that have been identified as influencing supply of agricultural commodities include producer price, area under crops, cost of capital, and technology.

However, the pricing policy is isolated as the single most important factor affecting supply and this has led to many researchers to concentrate only on responsiveness of supply to price. including other factors would improve the results of the study.

In sugar industry, few studies have been done concerning sugar supply in Kenya. This study will therefore essentially be different from other studies in that it will investigate the effects of SAPs and rainfall on sugar supply in Kenya. Three phases of SAPs can be identified in the period of this study. In the period 1970-79 no SAPs policies were in place. The period 1980 –92 represents a period of gradual SAPs policy implementation. From 1992-2003 the SAPS policy implementation process was deepened through Enhanced Structural Adjustment Facility (ESAF). The various phases of SAPs on sugar supply will be evaluated in this study.

The reason for incorporating other factors is because the price effect cannot easily be separated from the non-price effect and hence the need to know the share of each to production of sugar. In Kenya dry farming is practiced in sugar cane production and rainfall patterns would be expected to play an important role in production.

CHAPTER 3

3.0 METHODOLOGY

3.1 Theoretical Framework

Most models that have sought to investigate supply of agricultural commodities have based their studies on Nerlovian Model. Nerlove (1956) initial model established a relationship between long-run equilibrium of Acreage under an agricultural commodity to expectations He used Geometric Lag Model to develop a behavioral model in the supply of agricultural commodities. Lagged models have the advantage of incorporating expectations about the future, take into account length of the adjustment process, and makes the model dynamic. Nerlove postulated the hypothesis that each year farmers revise their price expectation for coming periods in proportion to the error they made in predicting the current prices. He starts off with the assumption that acreage planted of the crop bears a linear relationship to the expected price This assumption can be stated mathematically as:

$$X_t = a_0 + a_1 P^*_t + U_t \text{...(i)}$$

where X_t is the acreage of the crop planted in year t, P^*_t is the price farmers expect to prevail in year t, U_t is the random error term, and a_0 and a_1 are constant or regression parameters. The rationale of using acrearage and not output is that due to great seasonal variation of weather conditions, farmers tend to have little control over actual output and for that reason acrearage planted is a better approximation to farmers intended output for that period. It is difficult to estimate equation (i) as P^*_t cannot be observed. To overcome this, Nerlove applies the hypothesis that farmers revise their price expectation each year in proportion to error they made in predicting current prices. The hypothesis can be stated mathematically as follows:

$$P^*_t - P^*_{t-1} = \beta(P_{t-1} - P^*_{t-1}) \text{ ....(ii)}$$

Where $0 < \beta \leq 1$ is a coefficient of expectation. P^*_{t-1} is the price farmers expected to have prevailed in year t-1, and P_{t-1} is the actual price that farmers realized in year t-1

Equation (ii) may be re-written as follows:

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

Similarly we may write

$P^{*}_{t-1} = \beta P_{t-2} + (1-\beta) P^{*}_{t-2}$ and so on.

We may therefore write

$$P^{*}_{t} = \beta P_{t-1} + \beta(1-\beta) P_{t-2} + \beta(1-\beta)^2 P^{*}_{t-3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(iii)}$$

Since $0 < \beta \leq 1$ P^{*}_{t} is a weighted average of past realized prices with weights declining geometrically as we move back into the past. The significance of equation (i) and (iii) is that previous prices influence on farmers decision on acrearage but the more recent prices have a greater influence on farmers' decision than distant previous prices.

Equation (i) and (ii) may be combined to give:

$$X_t = a_0 + a_1 \beta \Sigma(1-\beta)^{i-1} P_{t-i} + U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(iv)}$$

Applying Koyck transformation to (iv) we get :

$$X_t = \pi_0 + \pi_1 P_{t-i} + \pi_2 X_{t-1} + V_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(V)}$$

Where $\pi_0 = a_0 \beta$ $\pi_1 = a_1 \beta$ $V_t = U_t - (1-\beta)U_{t-1}$ and $\pi_2 = (1-\beta)$

An attempt to estimate equation (v) creates a problem in that the new error term V_t is correlated with dependent variable X_{t-1} which is now included in the equation as an independent variable. OLS estimates are bound to be inconsistent. Nerlove gave an alternative rationalization procedure and formulated Partial Adjustment Model. The model is based on the argument that farmers are always trying to bring the actual output to some desired level, but due some uncontrollable factors like weather fluctuations, technological and financial constraints, such efforts are not completely successful in any one period. Partial Adjustment Model is discussed below in context of sugarcane crop.

Due to difficulties associated with expectation lag models, Adjustment Lag Model is best feasible choice, although it leads to over implication of expectation behaviour. Many researchers employ a modified form of Nerlovian Adjustment Lag Model.

NERLOVE PARTIAL ADJUSTMENT MODEL

Nerlove developed this model as an alternative way of overcoming problems created by Koyck transformation of Distributed Lag Model.

Partial Adjustment Model is adopted in this study to enable us to compute the short-run elasticities and long-run elasticities of supply. Many agricultural policies are classified as short-run policies and long-run policies. A model that would measure the responsiveness of policy variables (exogenous variables) to endogenous variables would provide more information to policy makers in the sugar industry and enable them to formulate short- and long-run policies. The model starts off by assuming the following relationship based on human behaviour.

$$Y^{*}_{t}=\beta_{o}+\beta_{1}[X_{t}]+\varepsilon_{t} \quad \text{...(i)}$$

Equation (i) means there is a desired level of sugar Supply (Y^{*}_{t}) in period t which depends on X in period t, X_t

If X_t is the price , then at a price level X_t the sugarcane farmers will desire to supply Y^{*}_{t} of sugar cane.

The desired level Y_t^{*} cannot be estimated because it is an expectation and not observable.

Because of the gestation period (2 years in case of sugar cane) involved and technological constraints, the realized change in sugarcane supply is only a fraction of the desired change. This is due to financial, technological, and managerial constraint experienced by cane farmers who therefore never fully achieve the desired level.

The adjustment process can be expressed through the following "adjustment equation":

$$Y_{t}-Y_{t-1}=\delta(Y_{t}^{*}-Y_{t-1})+V_{t} \quad \text{....................(ii)}$$

Where $Y_t - Y_{t-1}$=Actual change in cane supplied (realized sugarcane supply)

$Y^*_t - Y_{t-1}$= desired sugarcane supply by the farmers

δ = adjustment coefficient, $0 < \delta \leq 1$

Equation (ii) means that the achieved change ($Y_t - Y_{t-1}$) in sugarcane supply by the farmers is only a fraction of the desired change ($Y^*_t - Y_{t-1}$)

Substituting equation (i) i.e $Y^*_t = \beta_o + \beta_1 X_t + \varepsilon_t$ into equation (ii) we get

$$Y_t - Y_{t-1} = \delta (\beta_o + \beta_1 X_t + \varepsilon_t - Y_{t-1}) + V_t$$

Or

$$Y_t = \delta \beta_o + \delta \beta_1 X_t + (1-\delta) Y_{t-1} + (V_t + \delta \varepsilon_t) \quad \text{...(iii)}$$

Equation (iii) means the sugarcane supplied by the farmers at any period t depends partly on explanatory variable (X_t) and partly on level of sugar supply in previous period (Y_{t-1}). This forms justification of use of Partial Adjustment Model. X_t can be expanded to a vector of n-independent variables.

Model (iii) eliminates, the problems that arise from Koyck transformation of a distributed lag model of the form.

$$Y_t = \alpha_0 + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \beta_3 X_{t-3} + \text{-------} + \beta_s X_{t-s} + \xi_t \text{ ------ (iv)}$$

While koyck transformation of model (iv) has the advantage that it conserves degree of freedom and reduces multicollinearity to a great extent, it creates other problems (i.e autocorrelation, interdependence between Y_t and ξ_t and biasness and inconsistency). In model (iii) the error terms are not autocorrelated with its own previous values and OLS is applicable.

In Partial Adjustment Model (iii) the coefficient (1 -δ) of the lagged variable has an economic meaning since it involves the adjustment parameter and also suggest a relationship with Cob-Douglas production function. In the model (iii) the coefficient of Y_{t-1} is expected to be positive for non-durables and it would be negative for durables (Houthakker-Taylor, 1966).

Lagged models have advantage of incorporating expectations about the future, take into account the length of adjustment process of economic phenomena and make the model dynamic.

Short-run and Long-run elasticities

Nerlove (1958) formulated the following procedure for estimating short-run and long-run elasticities for agricultural commodities. This procedure is illustrated here as this study aims at computing short- and long-run elasticities.

Assume the long-run supply function of Cobb-Douglas form

$$S_{tL} = \beta_0 \cdot P_t^{\beta 1} \cdot Y_t^{\beta 2} \cdot U_t \quad \text{...(i)}$$

Where S_{tL} is the long-run supply at time t , P_t is producer price at time t and Y_t is an independent variable

In (i) a two – variable case is used for simplicity but it can be expanded to a multivariate case. The collected data show the short-run quantities supplied. To estimate the long-run elasticities and short-run elasticities, the following principle is followed.

The ratio $\frac{S_{tL}}{S_{t,s}}$ is closer to unity than the ratio $\frac{S_{tL}}{S_{t-1,s}}$. This is because there

will tend to be greater coincidence between short- and long-run in year t than between short- and long-run supply in successful years (nerlove and Addison, 1958). This implies that

$$\frac{S_{tL}}{S_{ts}} = \frac{(S_{tL})^{\lambda}}{(S_{t-1,s})^{\lambda}} \qquad \text{.......(ii)}$$

$0 < \lambda < 1$

By substituting (i) into (ii) and re-arranging, we get

$$S_{tL} = \frac{(S_{ts})^{1/1-\lambda}}{(S_{t-1,s})^{\lambda/1-\lambda}} = \beta_0 \,.\, P_t^{\beta 1} \,.\, Y_t^{\beta 2}\, U_t \qquad \text{.......(iii)}$$

Taking log of (ii) and re-arranging, we get

$$S_{ts} = \beta_0^{(1-\lambda)} \,.\, P_t^{\beta 1(1-\lambda)} \,.\, Y_t^{\beta 2(1-\lambda)} \,.\, S_{t-1,s}^{\ \lambda} \,.\, U_t$$

Or

$$S_{ts} = \beta_0^{*} \,.\, P_t^{\beta 1^*} \,.\, Y_t^{\beta 2^*} \,.\, S_{t-1,s}^{\ \beta 3^*} \,.U_t \qquad \text{.......(iv)}$$

Where

$\beta_1^* = \beta_1 (1-\lambda)$ and $\beta_1 = 1/(1-\beta_3^*)$

$\beta_2^* = \beta_2 (1-\lambda)$ $\beta_1 = 1/(1-\beta_3^*)$

$\beta_3^* = \lambda$ $\beta_1 = 1/(1-\beta_3^*)$

Equation (iv) is the short-run supply curve, from which we estimate both the short- and long-run elasticities, where the β^* s are the short-run elasticities and the β s are the long-run elasticities. The elasticity of the lagged supply gives the value of λ.

3.1 THE MODEL

This study uses a modified form of Nerlovian Adjustment Lag Model of the form described above. The model is popular in agricultural studies because it takes into account time lag in adjustment process and is a behavioral model.

$S_{ts} = f(P_t, A_t, R_t, , S_{t-1}, SAP)$

Which can be re-written in the form of model (iv) above as:

$$S_{ts} = \beta_0 \cdot P_{t-1}^{\beta 1} \cdot A_{t-1}^{\beta 2} \cdot R^{\beta 3}_{t-1} \cdot S_{t-2,s}^{\beta 4} \cdot e^{\varepsilon t}$$

Linearising the above equation, lagging by one period and including dummies, we get the double-log equation of the form

$$LnS_{ts} = Ln\,\beta_0 + \beta_1 LnP_{t-1} + \beta_2\,Ln\,A_{t-1} + \beta_3\,LnR_{t-1} + \beta_4 Ln\,S_{t-2} + D_1\,SAP_N + D_2\,SAP_M + D_3 SAP_H + \varepsilon_t$$

Where

S_{ts} = quantity of sugar supplied in time t

P_{t-1} = producer price of sugar cane at time t-1

A_{t-1} =acreage under sugarcane in time t-1

SAP_N =No SAPs period (1970-1979)

SAP_M = moderate SAPs (1980-92)

SAP_H = High/ enhanced SAPs (1993-03)

R_{t-1} = mean annual rainfall in sugar growing ecological zone in time t-1

S_{t-2} = lagged quantity of sugarcane supplied in t-2

D_1 = SAPs dummy (= 1 if period 1 (1970-79, 0 otherwise)

D_2 = SAPs dummy (= 1 if period 2 (1980-92), 0 otherwise)

D_3 = SAPs dummy (= 1 if period 3 (1993-03), 0 otherwise)

ε_t = disturbance term

SAP = Structural Adjustment Programme

(one dummy will be dropped to avoid ''dummy trap'')

$\beta_0\ \beta_1\ \beta_2\ \beta_3\ \beta_4\ \beta_2\ D_1\ D_2\ D_3$ are coefficients.

3.2 Estimation Technique

The simple model specified in section 3.2 will be estimated using Ordinary Least Squares (OLS). This technique will be applied to annual time series data covering the period 1970-2003. Structural breaks in sugar supply will be investigated and any problems such as autocorrelation, spuriousness and normality will be tested. Stationarity of the variables will be investigated using graphical method and Augmented Dickey-Fuller (ADF) unit root tests and order of integration established. If data is non-stationary cointegration of the variables will be investigated using Engel-Granger and Johannsen's procedure and based on results of cointegration, Vector/Error Correction Model (ECM) constructed. Granger causality, variance decomposition and Impulse Response Function (IRF) will also be investigated.

SAPs Dummies will be used to evaluate the effects of liberalization in the agricultural sector and also capture effects of uncontrolled importation/dumping of sugar. Prices of substitute such as maize, millet and sorghum may not influence sugarcane production to a large extent since it is a perennial crop and these crops are not mutually competing crops. Financial problems encountered by the farmers are incorporated in the model. These problems may be inability of farmers to buy inputs such as fertilizers, pesticides, herbicides and managerial and marketing problems.

3.3 Data type, Sources and limitations

The study aims at utilizing discrete multivariate time-series data on annual basis from 1970-2003. Such data will be collected from Kenya Sugar Board, Meteorological Stations, GoK official documents, Ministry of Agriculture, sugar industries, Economic Surveys, Agricultural production documents, Statistical Abstracts, Annual reports and publications.

Data limitations are certainly likely to exist in some areas. Data will be collected from several sources and there may arise problem of inconsistency. Some sources publish data, which may refer to different time periods from the unit time period used in the study and may raise problems of reliability. Unavailability of data and lack of up-to-date data are problems likely to be encountered in the course of data mining.

Attempts will be made to adjust the data and stick to the most consistent, authentic and reliable sources.

CHAPTER 4

4.0 FINAL RESULTS

This section describes the nature and characteristics of the data used for estimation. In particular we consider the measures of dispersion (range, minimum, maximum, standard deviation) and measures of central tendency (mean, median). It also provides descriptive analysis of data to provide some knowledge of the data used in the analysis. Time series data is usually influenced by seasonal variation, cyclical variation, trends and movements of other economic variables Correlation matrix of the independent is used to investigate any correlation between independent variables and graphical analysis is used to portray trends or/and structural breaks. This section also presents the estimated model results, tests for stationarity of the explanatory variables, tests for co-integration on the residual of non-stationary series and the estimation result of the dummies used to capture the non-observable influence of structural adjustments.

4.1 DESCRIPTIVE ANALYSIS OF DATA

4.1.1 SUMMARY STATISTICS OF THE VARIABLES.

The variables used in the study are as follows

Y- Quantity of sugarcane supplied by farmers to sugar factories (tonnes)

X1- Producer price of sugarcane to farmers

X2 –Area of sugarcane planted (in hectares)

X3 –Average annual rainfall in sugarcane growing zones (millimeters)

LY1-Lagged quantity of sugarcane supplied

Table 4.1 Summary Statistics

VARIABLE	MEAN	MEDIAN	STANDARD DEVIATION	MAXIMUM	MINIMUM	RANGE
Y	3274058	3633900	1076210	4661369	1062295	359906
X1	685.41	298.82	733.79	2015.81	45.01	1970.8
X2	78540.74	75350	34370.09	131130	26400	104730
X3	1467.42	1439	257.25	2224.6	1065.2	1159.4

Source: Author's calculation

The dependant variable (Y) measures the quantities of sugarcane supplied to the sugar industries by sugar cane farmers. The annual mean (average) quantity of sugarcane supplied to sugar industries is 3274058 tonnes. The maximum and minimum values are 4661361 and 1062295 metric tonnes respectively, with a range of 359906.

The independent variable (X1) captures the price paid to farmers per tonne of sugarcane delivered to sugar factories. It has a mean of 298.82, with standard deviation (average deviation from the mean) of 733.79 and maximum and minimum of 2015.81 and 45.01 respectively. Its range (difference between maximum and minimum) is 1970.8. The variables X3 measure the area in hectarage under sugarcane. The mean hectarage under sugarcane per year is 78540.74 with minimum area under sugarcane being 26400 (1973) and maximum of 131130 (2004). Rainfall (in millimeters) in the sugar-growing belt is measured by variable X3. The average annual rainfall in the sugar growing zones is 1467.42 millimeters with a maximum of 2224.6 and a minimum of 1065.2 millimeters. Rainfall pattern depicts a standard deviation of 257.25 and median of 1439.0 millimeters. Dummies D1(1970-79), D2 (1980-92) and D3 (1993-03) are used to capture qualitative influence of SAPs policies.

The variability as shown by the standard deviations of the various variables is relatively low suggesting that the variables were generally stable over the study period.

The Jarque-Bera statistics, which indicates the normality of the distribution of the variables, show that the variables are normally distributed (see appendix Table 1). The joint combination of these variables is normally distributed as shown by Jarque-Bera probability. The application of this task shows that the Jarque-Bera statistic is about 3.01 for the dependant variable and the probability of obtaining such a statistic under the normality assumption is about 22.1%. Therefore we do not reject the null hypothesis. OLS assumption requires that the error term is normally distributed. It does not emphasize the normal distribution of each variable used in the regression. Therefore the model for the regression passed normality test. All the variables depict positive skewness (mean greater than median) except the dependent variable, which has a negative skewness (median greater than mean). The standard deviation indicates the degree of symmetry about the average. The normal distribution is symmetrical about the mean. Kurtosis measures the third moment of a variable about its mean and degree of "peakedness". A normal distribution has a kurtosis of about 3.

4.2 Stationarity tests.

A time series is said to be stationary if its distribution remains invariance with respect to time. It is often difficult to represent time series with past and future intervals of time by simple algebraic models if the process is non-stationary. Use of non-stationary variables generate poor forecasts and result in spurious regression. A spurious regression has a high correlation co-efficient (R-squared) and a t-statistics that appear to be significant but without any economic meaning. However, if stationary, the process can be modeled with fixed co-efficient that can be estimated from past data. It is therefore necessary to test for stationarity in a time series model. A number of approaches exist for testing the stationarity of time series variables. Three techniques are used in this study to test for stationarity.

These are:

a) Graphical method
b) Correlogram
c) Dickey-Fuller Unit Root test.

Both the graphical method and the correlogram were popular in the 1970's and 1960's before the development of the unit root test by Dickey-fuller. The three procedures are used here to test the consistency of the variables.

4.2.1 Graphical Approach

The dependant variable Y (the quantity of sugarcane supplied) depicts an upward movement over the study period. This implies the variable is trending, (see appendix figure 1). Graphical analysis of price and hectarage show presence of trend. These variables are non-stationary. However, the rainfall variable shows a general horizontal movement over the study period, despite presence of structural breaks. The graphical analysis of the rainfall variable suggests stationarity. It is noted that graphical analysis of stationarity is not by itself conclusive as it is a "crude" test for stationarity. This calls for further tests for stationarity.

4.2.2 correlogram

The correlogram approach test for stationarity was popular in the 1970's and 1960's. The correlogram shows the autocorrelation against different lag lengths. Auto-correlation is the ratio of auto-covariance to variance. If the auto-correlation decays rapidly, the variable is stationary. If autocorrelation die gradually as lags increase, then the variable is non-stationary.

The autocorrelation of the dependent variable (Y), price (X1), area (X2) die gradually (see appendix) implying non-stationarity while the autocorrelation of rainfall variable (X3) die rapidly (see appendix, Table 2) indicating stationarity. The graphical and correlogram approaches yield consistent results.

4.2.3 Dickey-Fuller unit root test

We formally test for non-stationarity using Dickey-Fuller unit root test. The presence of a unit root indicates non-stationarity. We however use the augmented Dickey-fuller (ADF) and Phillip-Peron (PP) to test for order of integration (i.e. the number of times a variable is to be differentiated before it becomes stationary). The PP test takes into account the presence of structural breaks, which may exist in the study period.

a) Results of unit root test

In the table below, we present the result of the unit root test for the variable in levels (without differencing) and after 1st difference. We take log of variables to stabilize the variance.

As indicated in the table, the hypothesis of unit root cannot be rejected in all the cases using ADF. Since the t-values are less than critical values (in absolute terms), we can interpret these results as indicating all variables except rainfall are non-stationary in levels. Phillip Peron gives mixed results and therefore for unit root we focus more on the results based on ADF.

Table 4.2 Summary of Unit Root test

Variable	ADF TEST at levels	ADF TEST 1st difference	PHILLIP –PERON TEST at levels	PHILLIP –PERON TEST 1st difference
log Y	-1.94581	-4.81535	-1.67777	-5.56895
log X1	-1.01792	-4.08637	-0.82218	-5.07
log X2	-2.22862	-3.3696	-2.62286	-4.73649
log X3	-2.56505	-3.24747	-2.18109	-4 39839

The result for stationary test indicate presence of a unit root at 5% critical level or are integrated of order one I (1) and are thus non-stationary in levels but stationary (i.e. integrated of order zero I(0)) after first difference. This suggests that in order to eliminate the possibility of spurious regression and erroneous inferences, we should use the first difference of the relevant variables in the estimation. However, this may lead to loss of information that occurs from the attempts to address non-stationarity through differencing. The long run information will not be captured by differencing . According to Engel –Granger, differencing captures relationship only if a variable differs from long run equilibrium.

4.3 Correlation analysis

Correlation analysis assists in depicting the expected sign before the regression is carried out. Besides, it gives a quick check on whether the independent variables are correlated and whether this conforms to economic relationships. Two variables may have a positive correlation, a negative correlation or they may be uncorrelated (correlation=0). Variables that have positive correlation in relation to the dependant variable are producer price, area under sugarcane and rainfall. Structural Adjustment Programme (SAPS) dummies may depict either positive or negative correlation. On looking at the correlation matrix, the co-linearity between the variables is low (See appendix, Table 5). The vector of ones in the leading diagonal means that own correlation is 100%. The regression is able to identify effects of explanatory variables on the dependent variable. This also suggests the use of ordinary Least Squares (OLS) as an applicable procedure.

4.4 Co-integration Test.

Since all the variables are integrated of order one I(1), we suspect that the variables are co-integrated since co-integration theory argues that co-integrated variables have a linear combination that converges to equilibrium over time i.e. a combination that is stationary. Two or more variables are said to be co-integrated if individually the variables are non-stationary but their linear combination is stationary. When variables are co-integrated, it means they have a long-run equilibrium relationship.

It is therefore important that we test for co-integrating relationship amongst variables in order to have an econometric model that is plausible in the long run. If there is some tendency for some linear relationships to hold among a set of variables over long periods, co-integration task help to discover it.

4.4.1. Cointegration results

We proceed from the conclusion that all series in the model are non-stationary and become stationary after differencing (i.e. integrated of order I (1)). Co-integration of variables is tested using Engel and Granger (1987) two-stage algorithm approach. The residuals from long-run regression are generated and unit root test performed on them. This is based on the logic that if two variables are co-integrated, then this should be reflected on the residuals. The results of Engel-Granger co-integration procedure are presented in the appendix. The results reject the null hypothesis of no co-integration at 5% level of significance implying that co-integration exists between the variables. This means that the residuals of the co-integration equation is integrated of order zero I(0) (i.e stationary).

The results are further corroborated by inspection of the graph of the residual obtained from the long-run equation which depicts a horizontal movement implying stationarity (see appendix, figure 6.

4.3 EMPIRICAL RESULTS

Table 4.3 Final Estimation Results

The following table presents the regression results of the static equation showing the coefficient, standard errors, t-value, p-value for each of the variables in the regression equation.The explanatory variables collectively explain 91.37% of the variation in the dependent variable(sugar supply). Serial autocorrelation is found not to be serious (durbin-watson statistic is 1.77 which is less than 2). The F-statistic which shows the significance of correlation coefficient is 59.2. The significance (or insignificance) of the various explanatory variables is also shown in the table.

Table 4.3 REGRESSIN RESULTS

VARIABLE	COEFFICIENT	STANDARD ERROR	t-VALUE	P-VALUE	COMMENTS
LY1	0.044287	0.055766	0.794152	0.4340	Insignificant
LX1	0.216671	0.092705	2.337201	0.0271	Significant
LX2	1.088072	0.203808	5.338715	0.0000	Significant
LX3	0.376191	0.156719	2.400447	0.0235	Significant
D3	-0.392996	0.111862	-3.51054	0.0016	Significant
D2	0.238507	0.190698	1.250705	0.2218	Insignificant
C	0.420736	2.722781	0.154524	0.8783	Insignificant

Adj. R^2 =0.9137 DURBIN-WATSON STATISTIC = 1.77 F-STATISTIC =59.2

From the above regression results, three explanatory variables and one dummy variable are significant as 5% level of significance. These variables aware price (LX1), area (LX2), rainfall (LX3) and dummy variable of SAPS policy implementation period (D3). During regression one dummy variable (D1) was dropped to avoid "dummy trap". Lagged supply (LY1) as an explanatory variable and moderate SAPS dummy (D2) and the constant were found insignificant The significant variables have the expected signs.

The adjusted correlation coefficient is 0.9137, Durbin-Watson Statistic is 1.77 and the F-statistic is 59.25.

4.4 INTERPRETATION

The regression results imply the quantity of sugar cane supplied (LY) depends on producer price to farmers (LX1), area of sugarcane planted (LX2) and annual average rainfall (LX3) and the SAPS policies implementation dummy (D3). All these variables have appositive relationship to sugarcane supply. An increase of each of the explanatory variables (price, area and rainfall) will result in an increase of sugarcane supplied by farmers to sugar factories. In percentages, the result is interpreted as follows.

Since the estimating equation is a double –log the coefficients are elasticities. A 10% increase in the producer price of sugarcane will result in a 2.1% increase in the sugarcane supplied. A 10% increase in the average annual rainfall will result in 3.8 increase in the quantity of sugarcane supplied to sugar factories by sugar farmers. The adjusted R-squared of 0.9137 imply that those variables jointly explain 91.4% of the variation in sugarcane supplied. The Durbin-watson statistics of 1.77(approximately = 2) imply there is no serious serial correlation (autocorrelation). The f-statistic is significant implying the variable are jointly significant in influencing the dependent variable (LY1). Since the constant is not significant, it means there is no autonomous supply of sugarcane by farmers. The supply curve passes through the origin.

Interpretation of Dummy variables

The SAPS implementation period dummy D3 (1993-2004) is significant at 5% critical. The dropped dummy (D1) refers to no SAPS period (1970-1979). The significance of the coefficient of D3 implies that the coefficient of the D3 dummy is significantly different from the coefficient of the dropped dummy (D1). The co-efficient of the period of SAPS implementation is significantly different from the co-efficient of no SAPS. This represents a shift of the supply curve, with a constant slope. The intercept of the SAPS implementation period is different from the intercept of no SAPs due the shift of the supply curve. Since the coefficient is negative, SAPs implementation has adverse effects on sugarcane supply. The insignificance of the moderate

SAPS dummy (D2) imply that the moderate SAPs did not have a significance influence on the sugarcane supplied to sugar factories by the farmers.

4.3.1 Error Correction Model

If two variables are co-integrated, then they have long-run relationship. The long-run relationship would be reflected in the stationarity of the residuals. Engel and Granger Representation Theory suggests if two variables are co-integrated then we should incorporate the error correction term. Any deviation from the long-run path through the error correction term.

Applying the unit root test to the residuals from the regressive, it was found that the residuals were stationary, suggesting that variables were co-integrated. The results of the Error Correlation Model (ECM) are shown in appendix. Normal distribution of the error correction term is shown by the bell-shaped histogram (see appendix Figure 6).

The ECM model shows the short-run effects of changes in explanatory variables on the short-run changes in dependent variable and this can be compared to the long-run one.

The coefficient of Error Correction term (ECM) shows the speed of adjustment towards the long-run equilibrium relationship. The co-efficient of ECM has got the expected negative sign, implying that any deviation from long-run relationship will always tend to go back to the equilibrium position. If the coefficient is approximately equal to negative one, it indicates a high speed of adjustment (almost instant) adjustment. If speed of adjustment is approximately = 0, it indicates a very slow(almost non-existent) sped of adjustment to the long-run equilibrium. In this model a coefficient of -0.28 indicates a moderate speed of adjustment.

In the error correlation model, only producer price to farmers is found to be significant. The co-efficient of ECM is also significant at 5% critical level.

The only variable that is able to explain the sugarcane supplied to sugar factories by farmers both in short and long-run equations is the producer price to farmers. The significance and consistency of this variable in both regressions confirms this. The producer price variable is therefore of most interest to policy maker in the sugar industry.

4.3.2 Structural analysis

Analysis of the residuals shows that the residuals are stationary and distributed with mean zero as shown by figure (iv) in appendix and histogram of residuals. Jarque-Berra statistic of the residuals is 3 implying the residuals are normally distributed. The residuals are independent and identically distributed (IId). The following procedures for performing structural analysis are carried out:

(a) Granger Causality Test

A variable is said to be granger caused by another if the past and present information on a variable helps to improve the forecast of the other. Granger Causality test involves testing the significance of the unrestricted and restricted equation. The test involves an F-test.

If the P-value of the F-statistics is high we reject the null hypothesis of Granger Causality and accept the alternative hypothesis. Results of pair-wise Granger Causality tests are presented in the appendix, table 11. Granger Causality of independent variables and the dependent variable shows the results:

i. Producer price (LXI) Granger causes Sugarcane supplied (Ly)
ii. Acreage of sugarcane planted Granger causes quantity of Sugarcane supplied (Ly).
iii. Annual rainfall Granger causes quantity of Sugarcane supplied (Ly).

These results indicate that improving producer price of sugarcane, acreage under sugarcane and availability of water (e.g through irrigation) would improve the quantity of sugarcane supplied

(b) Impulse Response Function (IRF)

The impulse response function traces out the effects on exogenous shock or innovation on a variable. The response s are presented graphically in the appendix, figure 4. Thick error bands imply a greater variation as a result of a shock. The tapering of the error bands towards the zero point indicates convergence to long-run equilibrium.

C Variance Decomposition

Results of variance decomposition are presented graphically in the appendix. Variance decomposition describe the relative importance of exogenous shocks on an endogenous variable at different horizons. The result shows that quantity of sugarcane supplied is a dependent variable as most variation in this variable is explained by shocks in other variables at distant time horizon.

4.3.3 Long run and short run elasticities.

From the regression results of the static equation, we derive the short run and long-run elasticities using procedure illustrated in chapter 3. Since the co-efficient of the lagged supply is insignificant, we conclude the co-efficient is statistically equal to zero. The estimated equation is in the logs and the estimated coefficient are short-run elasticities. The short-run elasticities are also the long-run elasticities.

Table 4.4 Short-Run And Long Run Supply Elasticities.

variable	coefficient	short run elasticity	long run elasticity
price (LX1)	0.216	0.216	0.216
area (LX2)	1.088	1.088	1.088
Rainfall (LX3)	0.376	0.376	0.3761

A 10% increase in the producer price will lead to 2.16 increase in the quantity supplied both in the short-run and in the long-run. A 10% increase in the area planted will lead to 10.88% increase in the quantity of sugarcane supplied both in the short-run and in the long-run. A 10% increase in the average annual rainfall will lead to a 3.76% increase in the short-run and in the long-run. This result suggests the elasticities are constant in the short run and long-run. Any short-run policy would have more or less a permanent effect on the quantity of sugarcane supplied.

CHAPTER 5

5.0 CONCLUSION AND POLICY RECOMMENDATIONS

The broad objective of this study was to investigate the factors that influence the supply of sugarcane. The producer price of sugarcane was found to influence supply of sugar cane Hectarage under sugarcane and rainfall were found to be very significant factors influencing supply in any period.

The SAPs variable was significant at policy implementation phase and was found to adversely affect supply. The supply of sugarcane in previous period (lagged supply) was found not to influence output.

There are some factors which were not incorporated in the estimated model but play an important role in the supply of sugarcane. These factors are:

First, research and technological constraint could influence supply. Research may result in high yielding sugarcane and influence output.

Problems of hard and land tenure also pose a limitation to production. In some areas that are viable for sugarcane production, land remains unadjudicated and this limit the area available for acreage expansion.

Third, infrastructural constraints arise especially in areas which are not served with roads, constraining transportation of harvested cane to the factories This problem is especially serious during the rainy season.

Fourth, a problem of finance arise when Agricultural Finance Corporation has a shortage of funds. Many commercial sources are reluctant to give credit level to small scale holders

Fifth, the impact of extension services has not been empirically investigated in this study. Types of soils and inputs used may also affect output. Data on cane variety was not available as sugar companies pay uniform price irrespective of cane variety.

Six, farmers in a particular zone lack market alternative due to the monopsonistic nature of sugar companies in a particular zone. Alternative market structure may influence producer prices of sugarcane.

5.1 Policy Implication

The Empirical results imply several policy issues for accelerating the supply of sugarcane. The producer price to farmers was found to be an important factor influencing the output. This implies that the producer price of sugarcane should be made more favourable for farmers. This could be done by reviewing the producer price annually. Area under sugarcane was found to be an important variable in influencing sugarcane output. This suggests that extensive methods of production should be practiced.

Annual rainfall was found to have a positive impact on sugarcane output. Ways of employing irrigation methods in the production of sugarcane should be explored. Results of Granger Causality test indicate that improving producer price of sugarcane, acreage under sugarcane and availability of water (e.g through irrigation) would improve the quantity of sugarcane supplied. The SAPs policy implementation phase was found to adversely affect the output of sugarcane. This calls for a redress of SAPs and the way they were implemented. Liberalization of prices and sugar imports should be done in favour of farmers and farmers should be cushioned against adverse effects of SAPs.

There is need to liberalize the marketing of sugarcane. Monopoly in the marketing of sugarcane may discourage farmers. Farmers should be left free to market their produce and this may increase returns to farmers.

Empirical results imply that previous yield of cane does not affect sugarcane supply at any given period. This may be because cane is a highly perishable industrial crop and cannot be stored even if farmers expect better prices in the future.

Although this study concludes that producer-price elasticities of the various factors are the same in the short- and long-run, different policies may be applied in the short- and long-run, as the study did not include all the factors that influence sugarcane supply in Kenya.

5.2 Suggestion for further Research.

The supply of sugar is affected by many factors but this study has considered only a few of them leaving out the rest. The model used also does not capture all the variables that impact on the dependent variable.

Also there is a problem of how to separate the influence of each variable when they may be mutually reinforcing and may even be dependent on the price factor. For example, the acreage of cane planted may depend on the producer price paid to farmers.

The impact of research, extension services, sugarcane variety, agricultural credit to farmers and differences in output in various agro-ecological zones may provide insights of other factors that may influence sugarcane supply and provide areas for further research.

Bibliography

Binswanger H.P. & Yang M. (1987) "On the determinants of cross-Country Aggregate Agricultural supply" Journal of Econometrics

Bond M. E. (1983) "Agricultural Responses to Prices in African Countries". World Bank Development Report

Coughlin (1986) " Decisions and their financial Implication" Work paper, Friendrich Ebert Foundation, IDS Nairobi University pp. 51-54

Georgesue – Roegen, N "The economics of production functions" Journal of farm economics Vo.39 (1957) pp.8-12

Gujarati, D. (2003) Basic Econometrics, McGraw-Hill International Editions (4th Edition) pp. 690-706.

Howtrey, R. "Production Functions and Land; A new approach". Economic journal Vol.70 (1960) pp. 118-124

Kabagombe C., Odada E. Rural Development in Eastern and Southern Africa

Kabubo J. W Factors influencing the supply of wheat in Kenya. M. A Thesis, University of Nairobi

Kirori & Gitu (1991) Aggregate agricultural Supply response for selected Crops. MPND, Nairobi

Krishna R. (1963) Farm Supply response in India-Pakinstan A case Study of Punjab region. Economic Journal vol. 73

Maitha J. K. (1970) Productivity response to price: A case study of Kenya Coffee. East Africa economic Review vol.2 pp. 31-37

Maitha J. K. (1974) A note of Distributed Lag Model for maize and wheat production responses. The Kenyan case, Journal of Agricultural Economics, vol.25 no. 2

Mbogoh, S. G. "An economic Analysis of Kenya's Sugar Industry, with special reference to the self-sufficiency production policy" Nairobi University.

Mwega F. (1995) Trade liberalization, credibility and Impacts: A case study of Kenya 1972-94, AERC

Nerlove M. A. (1958) The dynamics of Supply: Estimation of Farmers Response to Price.

Nerlove, M. (1959) "Estimates of elasticities of Supply of selected Agricultural commodities". Journal of Farm Economics. Vol.38, pp496-502

Obidegwu C. F (1990) Adjustment programmes and economic change in sub-Saharan Africa.

Odada J. E. (1976) "The role of Sugar Industry in Kenya Economy: A case study of Lake Victoria Basin". PhD thesis. IDS Nairobi University, pp. 67-71.

Odada J. E. (1986) "Incentives for Increased Agricultural Production: A case study of Kenya's Sugar Industry" Working Paper, Friendrich Ebert Foundation, IDS Nairobi University pp. 12-18.

Odhiambo, M. O. The structure and performance of Kenya's Sugar Industry with special look on Nyanza Sugar belt, Msc Thesis University of Nairobi (1978)

Ogendo, R. R. & "The East African Sugar Industry" Geojournal. Vol2.4(1978) pp.343-354

Republic of Kenya (1986) Sessional Paper No.1 Economic Management for Renewed Growth.

Republic of Kenya Economic Review of Agriculture. Government Printer Vol.7 pp. 36-41.

Republic of Kenya National Development Plans.

Senga W. Heyer J. et al (1976) Agricultural Development in Kenya

Ssemogerere (1990) Structural Adjustment Programme (SAPs) and Coffee sector in Uganda, 1981-1987 AERC Research Paper.

Wambia, J. M. "An evaluation of the Kenya Sugar Industry: The case of Mumias Sugar Scheme" MSc thesis University of Nairobi (1979)

Appendix

TABLE 1 Descriptive Statistics

	Y	X1	X2	X3
Mean	3274058.	685.4103	78540.74	1467.424
Median	3633900.	298.8250	75350.00	1438.950
Maximum	4661361.	2015.810	131130.0	2224.600
Minimum	1062295.	45.01000	26400.00	1065.200
Std. Dev.	1076210.	733.7897	34370.09	257.2468
Skewness	-0.788581	0.810311	0.024409	0.986924
Kurtosis	2.187377	1.915075	1.551086	3.939963
Jarque-Bera	4.459382	5.388257	2.977456	6.771109
Probability	0.107562	0.067601	0.225660	0.033859
Observations	34	34	34	34

TABLE 2 Correlogram Test of Stationarity

Log of Y .

Date: 09/10/04 Time: 17:18

Sample: 1970 2003

Included observations: 34

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |*******|	. |*******|	1	0.884	0.884	28.956	0.000
. |****** |	.*| . |	2	0.752	-0.131	50.586	0.000
. |***** |	.*| . |	3	0.607	-0.131	65.155	0.000
. |**** |	. |*. |	4	0.512	0.147	75.845	0.000
. |*** |	.*| . |	5	0.417	-0.089	83.176	0.000
. |**. |	.*| . |	6	0.306	-0.172	87.281	0.000
. |* . |	.*| . |	7	0.185	-0.081	88.828	0.000
. |* . |	. | . |	8	0.072	-0.043	89.071	0.000
. | . |	. |*. |	9	0.014	0.136	89.081	0.000

Log of X1

Date: 09/10/04 Time: 17:21

Sample: 1970 2003

Included observations: 34

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |*******|	. |*******|	1	0.927	0.927	31.898	0.000
. |****** |	.*| . |	2	0.843	-0.123	59.071	0.000
. |****** |	. | . |	3	0.757	-0.049	81.694	0.000
. |***** |	.*| . |	4	0.665	-0.089	99.761	0.000
. |**** |	. | . |	5	0.581	0.003	114.01	0.000
. |**** |	. | . |	6	0.502	-0.021	125.04	0.000
. |*** |	.*| . |	7	0.422	-0.063	133.13	0.000
. |*** |	. | . |	8	0.345	-0.043	138.73	0.000
. |**. |	.**| . |	9	0.247	-0.211	141.72	0.000

Log of X2

Date: 09/10/04 Time: 17:24

Sample: 1970 2003

Included observations: 34

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |*******|	. |*******|	1	0.914	0.914	31.010	0.000
. |****** |	.*| . |	2	0.826	-0.064	57.079	0.000
. |****** |	. | . |	3	0.739	-0.036	78.626	0.000
. |***** |	. | . |	4	0.658	-0.015	96.275	0.000
. |**** |	.*| . |	5	0.574	-0.066	110.18	0.000
. |**** |	.*| . |	6	0.489	-0.063	120.61	0.000
. |*** |	.*| . |	7	0.400	-0.072	127.88	0.000
. |**. |	.*| . |	8	0.313	-0.058	132.50	0.000
. |**. |	. | . |	9	0.232	-0.033	135.13	0.000

Log of X3

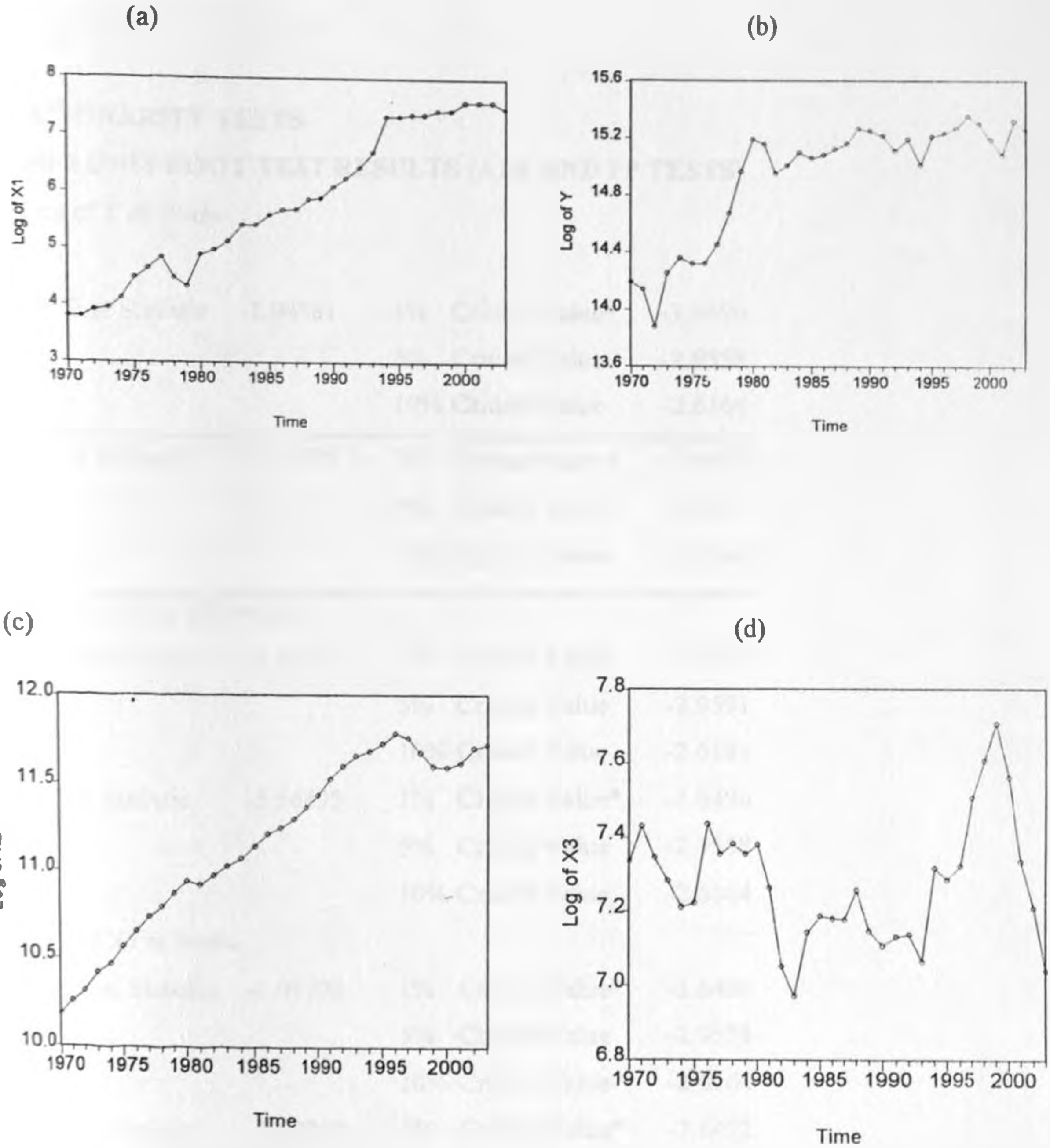
Date: 09/10/04 Time: 17:26

Sample: 1970 2003

Included observations: 34

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |****** |	. |****** |	1	0.727	0.727	19.622	0.000
. |*** |	.**| . |	2	0.400	-0.273	25.756	0.000
. |* . |	.*| . |	3	0.112	-0.138	26.253	0.000
.*| . |	. | . |	4	-0.080	-0.049	26.511	0.000
.*| . |	. | . |	5	-0.160	0.001	27.594	0.000
.**| . |	.*| . |	6	-0.194	-0.082	29.236	0.000
.*| . |	. | . |	7	-0.152	0.055	30.280	0.000
.*| . |	. | . |	8	-0.087	-0.003	30.640	0.000
.*| . |	.*| . |	9	-0.075	-0.117	30.913	0.000

Figure 1 Graphical Representation



STATIONARITY TESTS

Table 3 UNIT ROOT TEST RESULTS (ADF AND PP TESTS)

1. Log of Y at levels

ADF Test Statistic	-1.94581	1% Critical Value*	-3.6496
		5% Critical Value	-2.9558
		10% Critical Value	-2.6164
PP Test Statistic	-1.67777	1% Critical Value*	-3.6422
		5% Critical Value	-2.9527
		10% Critical Value	-2.6148

Log of Y at first difference

ADF Test Statistic	-4.81535	1% Critical Value*	-3.6576
		5% Critical Value	-2.9591
		10% Critical Value	-2.6181
PP Test Statistic	-5.56895	1% Critical Value*	-3.6496
		5% Critical Value	-2.9558
		10% Critical Value	-2.6164

.2 Log of X1 at levels

ADF Test Statistic	-1.01792	1% Critical Value*	-3.6496
		5% Critical Value	-2.9558
		10% Critical Value	-2.6164
PP Test Statistic	-0.82218	1% Critical Value*	-3.6422
		5% Critical Value	-2.9527
		10% Critical Value	-2.6148

Log of X1 after first difference

ADF Test Statistic	-4.08637	1% Critical Value*	-3.6576
		5% Critical Value	-2.9591

		10% Critical Value	-2.6181
PP Test Statistic	-5.07000	1% Critical Value*	-3.6496
		5% Critical Value	-2.9558
		10% Critical Value	-2.6164

3 Log of X2 at levels

ADF Test Statistic	-2.22862	1% Critical Value*	-3.6576
		5% Critical Value	-2.9591
		10% Critical Value	-2.6181
PP Test Statistic	-2.62286	1% Critical Value*	-3.6422
		5% Critical Value	-2.9527
		10% Critical Value	-2.6148

Log of X2 after first difference

ADF Test Statistic	-3.36960	1% Critical Value*	-3.6576
		5% Critical Value	-2.9591
		10% Critical Value	-2.6181
PP Test Statistic	-4.73649	1% Critical Value*	-3.6496
		5% Critical Value	-2.9558
		10% Critical Value	-2.6164

4 Log of X3 at levels

ADF Test Statistic	-2.56505	1% Critical Value*	-3.6496
		5% Critical Value	-2.9558
		10% Critical Value	-2.6164
PP Test Statistic	-2.18109	1% Critical Value*	-3.6422
		5% Critical Value	-2.9527
		10% Critical Value	-2.6148

Log of X3 after first difference

ADF Test Statistic	-3.24747	1% Critical Value*	-3.6576
		5% Critical Value	-2.9591
		10% Critical Value	-2.6181

PP Test Statistic	-4.39839	1%	Critical Value*	-3.6496
		5%	Critical Value	-2.9558
		10%	Critical Value	-2.6164

Table 5.4 Cointegration Analysis Results

ADF Test Statistic	-3.655728	1%	Critical Value*	-3.6576
		5%	Critical Value	-2.9591
		10%	Critical Value	-2.6181

*MacKinnon critical values for rejection of hypothesis of a unit root.

Table 5.5 Correlation Matrixes

	LY	LX1	LX2	LX3
LY	1	0.795422744	0.890922767	-0.108583827
LX1	0.795422744	1	0.062659222	0.114407772
LX2	0.890922767	0.062659222	1	-0.020690933
LX3	-0.108583827	0.114407772	-0.020690933	1

Figure 6 Graph of Residuals

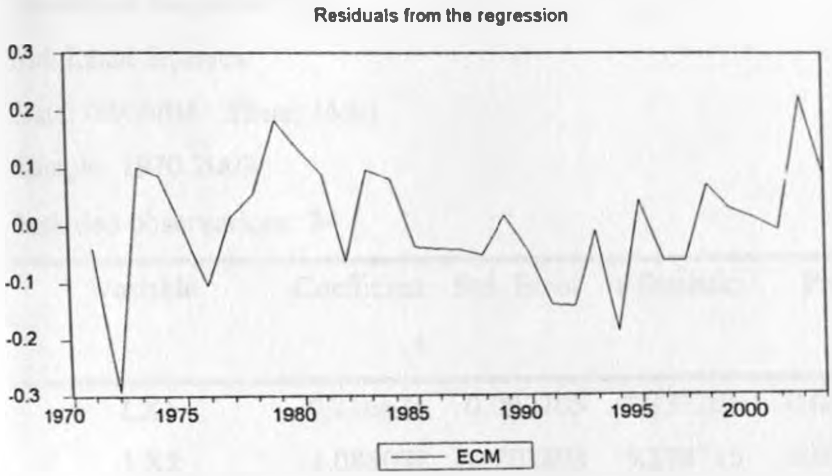


Table 7. Regression Results (Long-Run Regression)

Dependent Variable: LY

Md: Least Squares

Date: 09/09/04 Time: 15:01

Sample: 1970 2003

Included observations: 34

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LX1	0.216671	0.092705	2.337201	0.0271
LX2	1.088072	0.203808	5.338715	0.0000
LX3	0.376196	0.156719	2.400447	0.0235
LY1	0.044287	0.055766	0.794152	0.4340
D3	0.392696	0.111862	3.510524	0.0016
D2	0.238507	0.190698	1.250705	0.2218
C	0.420736	2.722781	0.154524	0.8783

R-squared	0.929412	Mean dependent var	14.92961
Adjusted R-squared	0.913725	S.D. dependent var	0.417641
S.E. of regression	0.122672	Akaike info criterion	-1.177369
Sum squared resid	0.406305	Schwarz criterion	-0.863119
Log likelihood	27.01528	F-statistic	59.24991
Durbin-Watson stat	1.174223	Prob(F-statistic)	0.000000

Table 8 Regression Results (Differenced Model)

Dependent Variable: DLY

Method: Least Squares

Date: 09/10/04 Time: 14:42

Sample(adjusted): 1971 2003

Included observations: 33 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLX1	0.306958	0.148490	2.067194	0.0488
DLX2	0.760874	0.709399	2.072561	0.0033
DLX3	0.168273	0.220413	2.763446	0.0521
DLY1	-0.24802	0.190361	-1.302957	0.2040
D2	0.189767	0.169491	1.119633	0.2731
D3	0.206832	0.182407	2.133904	0.2672
C.	3.589019	2.735841	1.311852	0.2010

R-squared	0.737322	Mean dependent var	0.032232
Adjusted R-squared	0.61319	S.D. dependent var	0.142789
S.E. of regression	0.138342	Akaike info criterion	-0.932351
Sum squared resid	0.497598	Schwarz criterion	-0.614910
Log likelihood	22.38379	F-statistic	1.348401
Durbin-Watson stat	1.695895	Prob(F-statistic)	0.272093

Table 9 Regression Including Error Correction Model (ECM-1)

Dependent Variable: DLY

Method: Least Squares

Date: 09/10/04 Time: 16:11

Sample(adjusted): 1972 2003

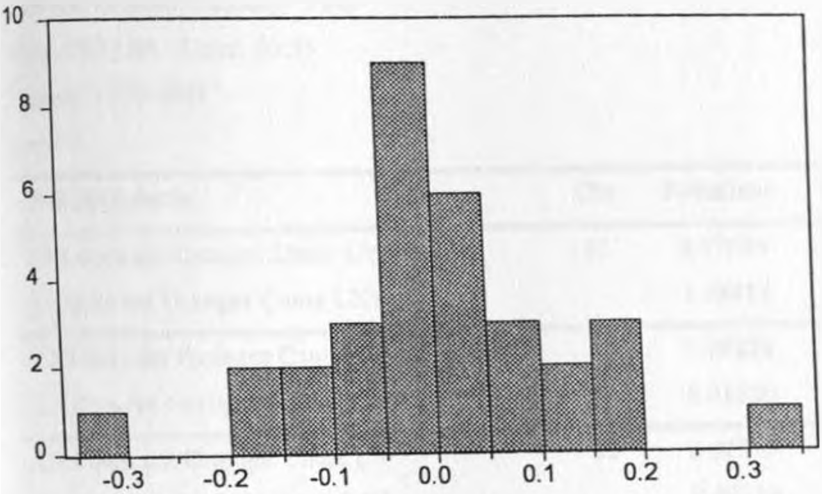
Included observations: 32 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLX1	-0.263314	0.151611	-1.736770	0.0952
DLX2	0.726712	0.752126	0.966210	0.3436
DLX3	0.168518	0.229702	0.733637	0.4703
D2	-0.023910	0.068668	-0.348197	0.7307
D3	-0.046958	0.081525	-0.576003	0.5700
DLY1	-0.042823	0.195602	-0.218928	0.8286
ECM_1	-0.289993	0.257010	-1.128336	0.2703
C	0.060933	0.074542	0.817435	0.4217

R-squared	0.266790	Mean dependent var	0.034744
Adjusted R-squared	0.052937	S.D. dependent var	0.144331
S.E. of regression	0.140459	Akaike info criterion	-0.875490
Sum squared resid	0.473487	Schwarz criterion	-0.509056
Log likelihood	22.00783	F-statistic	1.247537
Durbin-Watson stat	1.801931	Prob(F-statistic)	0.316862

Figure 10

Histogram For Residuals



Series: RESID
Sample 1972 2003
Observations 32

Mean	7.59E-18
Median	-0.009510
Maximum	0.342646
Minimum	-0.336007
Std. Dev.	0.123587
Skewness	0.116556
Kurtosis	4.486110
Jarque-Bera	3.017153
Probability	0.221225

Table 11 Pairwise Granger Causality Tests

Pairwise Granger Causality Tests

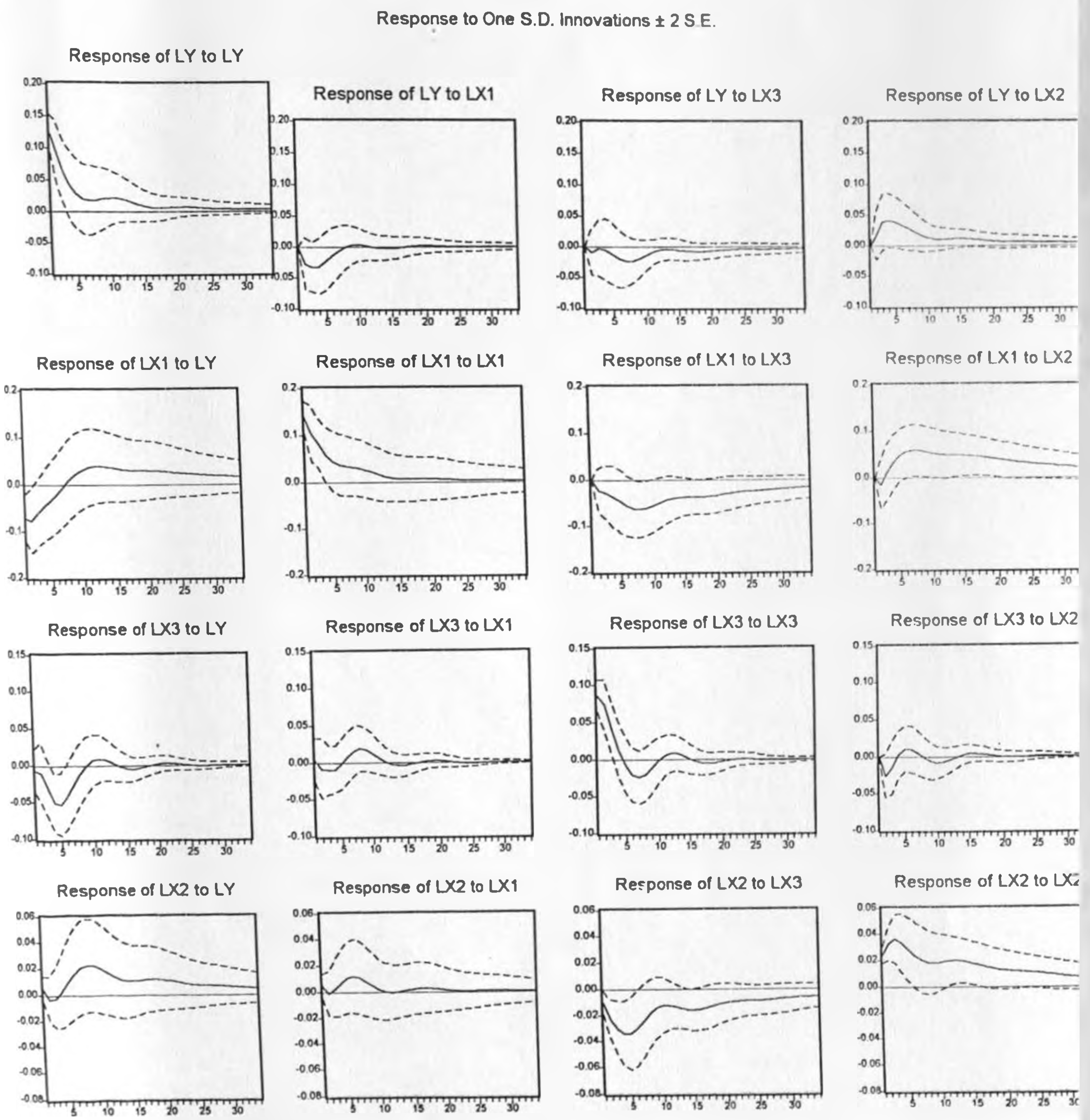
Date: 09/11/04 Time: 16:38

Sample: 1970 2003

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
LX1 does not Granger Cause LY	32	0.47049	0.62972
LY does not Granger Cause LX1		1.38413	0.26776
LX2 does not Granger Cause LY	32	1.19229	0.31901
LY does not Granger Cause LX2		3.01350	0.06587
LX3 does not Granger Cause LY	32	0.00385	0.99616
LY does not Granger Cause LX3		0.40318	0.67215
LX2 does not Granger Cause LX1	32	3.23695	0.05494
LX1 does not Granger Cause LX2		0.12345	0.88436
LX3 does not Granger Cause LX1	32	1.02395	0.37270
LX1 does not Granger Cause LX3		0.19898	0.82075
LX3 does not Granger Cause LX2	32	2.04449	0.14901
LX2 does not Granger Cause LX3		0.18097	0.83547

Figure (12)


Response to One S.D. Innovations ± 2 S.E.
Response of LY to LY
Response of LY to LX1
Response of LY to LX3
Response of LY to LX2
Response of LX1 to LY
Response of LX1 to LX1
Response of LX1 to LX3
Response of LX1 to LX2
Response of LX3 to LY
Response of LX3 to LX1
Response of LX3 to LX3
Response of LX3 to LX2
Response of LX2 to LY
Response of LX2 to LX1
Response of LX2 to LX3
Response of LX2 to LX2