FACTORS INFLUENCING THE SUPPLY OF COTTON IN KENYA (1960-2017)

BY

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NOVERMBER, 2018

DECLARATION

I, the undersigned, declare that this project is my original work and to the best of my knowledge has not been presented in any other university or institution for academic credit.

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Signature.. Date...................................

This research project has been submitted for examination with my approval as the university supervisor.

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Any mistakes and errors in this paper are, however, mine and should not be blamed on anybody else.

LIST OF ABBREVIATIONS

ACTIF	African Cotton & Textile Industries Federation
AGOA	African Growth Opportunity Act
ASAL	Arid and Semi-Arid Lands
ASDS	Agricultural Sector Development Strategy
CODA	Cotton Development Authority
EPZA	Export Processing Zones Authority
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
KenInvest	Kenya Investment Authority
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KNBS	Kenya National Bureau of Statistics
PPP	Public Private Partnership
SAL	Structural Adjustment Lending
SAPs	Structural Adjustment Policies
SSA	Sub Saharan Africa
USA	United States of America
USAID	United States Agency for International Development

ABSTRACT

Demand for cotton still supersedes its production and as such, the textile industry greatly relies on cotton lint imports to meet its yearly demand. Even with the sector's downturn in the current years, cotton is nonetheless one of the few cash crops that has the ability of expanding food security and employment opportunities through income generation in the Kenyan ASALs. The main objective of the study was to assess the factors influencing the supply of cotton in Kenya with the objective of proposing policy measures to increase production. The study adopted a modified Nerlovian supply response model to estimate both output and hectarage model. Secondary time series data for the period 1960-2017 was used and analyzed using Stata version 15.1. Findings from the study showed that government expenditure on research, price of inputs and hectarage planted to cotton in the present period were the significant factors influencing output of cotton. Hectarage planted to cotton in the previous period was found to be the only significant factor influencing hectarage planted to cotton. The study recommends among other things the strengthening of the linkages between cotton output and research and allocation of adequate funds to research in cotton. Farmers are encouraged to make use of all the available 385,000 hectares that is viable for production. Further, the government should introduce subsidies that lower the cost of inputs which take a huge chunk of production costs. This will encourage cotton producers to increase their production.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Kenya has the largest and most diversified economy in East Africa with agriculture as the backbone of the economy (USAID, 2018). The sector accounts for more than a quarter of the country's Gross Domestic Product (GDP) and 80 percent of national employment, majorly in rural areas (KIPPRA, 2017). The sector also provides more than 60 percent of the total export earnings, and approximately 45 percent of government revenue at the same time offering majority of the country's food needs. The sector is approximated to have an additional indirect contribution of approximately 25 percent of GDP via linkages with distribution, manufacturing as well as other service related sectors (Kenya, Ministry of Agriculture, 2016). Poverty dynamics in Kenya are evolving and this affects the country's agricultural sector directly. Presently, 46 percent of the populace lives on less than one dollar a day, 35 percent of children under five are stunted and 35.6 percent are food insecure (FAO, 2018). Given the importance of agriculture in Kenya's rural areas where poverty is prevalent, the sector's importance in alleviating poverty cannot be underestimated (FAO, 2018).

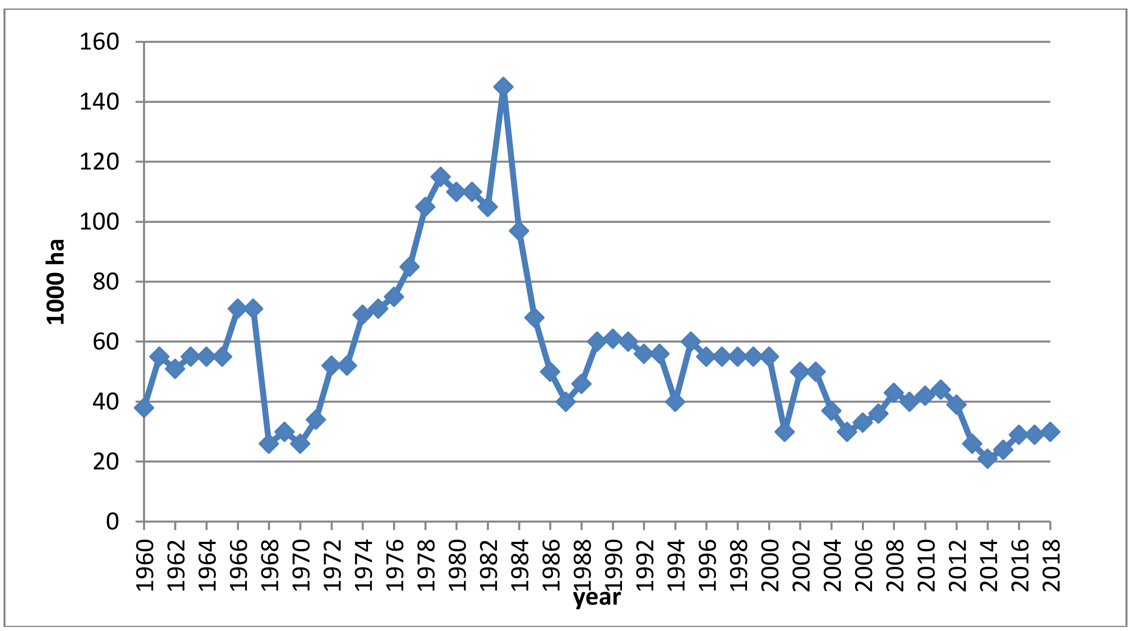
The agricultural sector has policy and institutional frameworks in place that help in steering the sector like the 2009-2020 Agriculture Sector Development Strategy (ASDS) as well as other sub sector policies (ACTIF Report, 2013). These policies aim at raising agricultural productivity through exploiting the potential for irrigation, value addition, advocating for relevant technologies, ensuring the right legal and policy frameworks, land development, increased commercialization of agricultural activities, increasing financial resources, implementing proper governance of agricultural institutions and promoting sustainable management of resources. The primary role of the institutions involved is to carry out innovative research that is of national importance. Establishment of such institutions is aimed at distributing the right technologies, knowledge, and information with the objective of magnifying the effectiveness of the sector as well as increasing output. A significant policy change in the cotton sector was the proclamation of the 2006 Cotton Amendment Act that brought into being the Cotton Development Authority (CODA) which was mandated to promote, regulate, and coordinate the cotton industry in Kenya. CODA replaced the Cotton Board of Kenya, a move that saw regulation and authority move from the state to industry shareholders like cotton producers, ginners, and manufacturers (CGD, 2005).

Cotton is a vital crop in Kenya acting as a raw material in the production of vegetable oil, an income source for small scale farmers, and previously one of the main foreign exchange currency earners as well as providing employment opportunities (Jones and Mutuura 1989). Its cultivation contributes to the amelioration of small scale farmers' livelihoods and the attainment of food security. The Kenyan government policy, Kenya Vision 2030 identified cotton as an important sub sector with the ability of positively affecting the lives of eight million individuals in the ASALs of the country (Kenya Vision 2030).

The development of Kenya's cotton industry has undergone several phases, from control by private colonialists to structuring of cooperative societies that were formed with the aim of buying out cotton ginneries from colonialists (Anthony and Brown, 1970). Cotton production was introduced in Kenya in 1902 (Burrow, 1975; Ikitoo, 1977) by the British colonial administrators. The Cotton Lint and Seed Marketing Board was formed in 1953 with the mandate of producing, processing and marketing cotton. Cooperatives were also established to undertake the role of input supply and payment to farmers. It was not up to the early 1960s that cotton was launched in several area of the nation, being advocated for in zones with low rainfall that were unfavorable for other cash crops. Private colonial ginners dominated the cotton subsector until 1963 (Aldington, 1971). After independence, the country resorted to an import tradeoff approach which warranted a reverse consolidation of textile mills. Between that period and the close of 1990, the Kenyan government inaugurated jurisdictions in the sector by helping cooperative societies to acquire ginneries from colonialists, controlling marketing margins, fixing producer prices as well as investing greatly in textile mills. The local industry was protected by the government through imposition of a 100 percent duty on imported commodities, a move that guaranteed quick prosperity of the local textile industry with a mean production potential of above seventy percent. In the early 1990s, the government liberalized the sector. Government support began to reduce and the market was liberalized. A sector that had been protected for several decades was not ready to compete with cheap import from Asian suppliers. This led to a decline in cotton production. Eventually, there was an influx of imported goods in the local market which accelerated the downward spiral of the cotton industry. AGOA came into force and the cotton sector began on a recovery path, albeit slowly. The government, upon realizing the employment and export potential of the cotton sector, announced various policy measures to attract investment in the cotton, textile and apparel sector as well as enhancing exports.

In 2014, Kenya replaced Lesotho as the main garment exporter to the USA under AGOA. Kenya is expected to remain as the largest beneficiary of the recent 10 year extension of AGOA (KenInvest, 2016). The textile industry has produced a remarkable contribution to generating income in rural locales by offering a large market for cotton. The sector has various linkages not limited to textile manufacturing and processing industry, but also with manufacturers of animal feeds, fats and oils, soaps and detergents to mention but a few. Such direct linkages with textile manufacturing and processing firms are important mainly because of new market opportunities offered by the European Union, AGOA, and other markets where Kenya can export her cotton. Kenya possesses 385,000ha (350,000 rain-fed and 35,000 irrigated) of land favorable for cotton cultivation but barely a fraction of it is under production (KenInvest, 2015). Figure 1 below shows the area under cotton in Kenya.

Figure 1: Area under cotton in Kenya 1960-2018 (‘000ha)

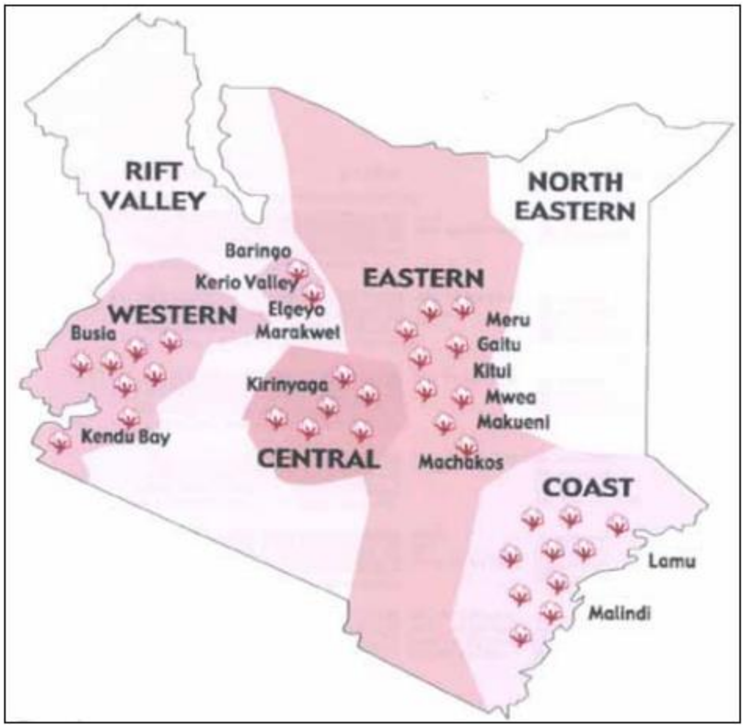


Source: (KNBS statistical abstracts)

1.1.1 Cotton production in Kenya

Approximately 200,000 farmers are engaged in cotton production in Kenya. Majority of the cotton is grown on holdings of below one hectare (KenInvest, 2016). Figure 2 below shows the cotton growing regions in Kenya.

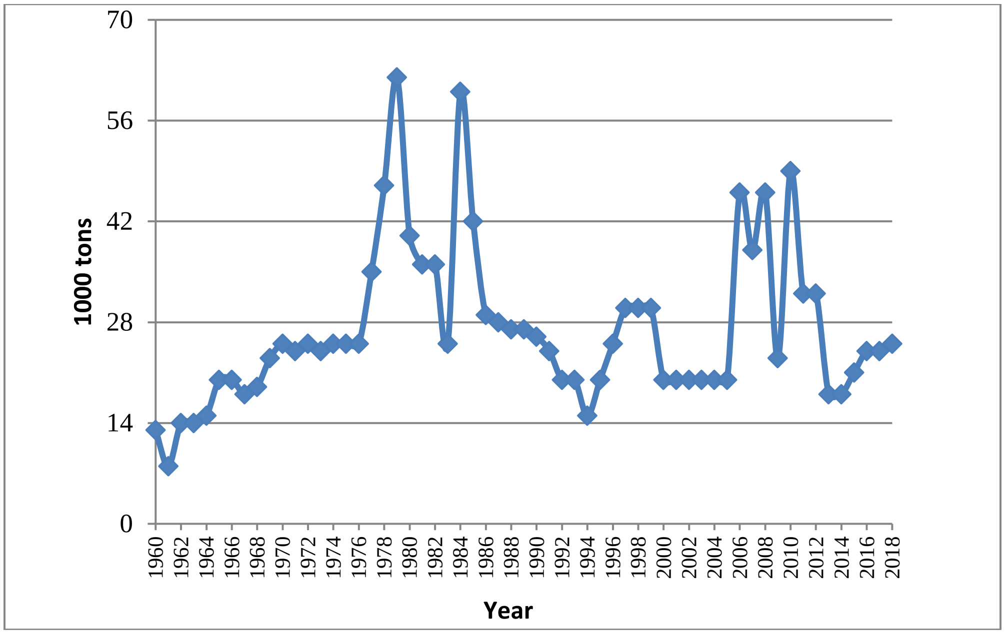
Figure 2: Main cotton growing areas in Kenya



Source: (CODA, 2010)

The varieties of cotton in Kenya include Gossypium barbadense and Gossypium hirsutum (Kiranga, 2013). Cotton grows on lowland below 1000m, requires optimum temperature of 34^{o}C and average rainfall of between 800-1200mm. Kenya has embraced the genetically modified BT cotton seeds to raise output. The seeds have adopted well because they do not need pesticide spraying and its productivity doubles that of the traditional seeds (Kiranga, 2013). Kenya can produce 260,000 bales of cotton provided hectarage is increased. Currently, cotton is cultivated barely on 25,000 hectares and is valued at approximately Kshs.179 million, with yearly lint production of 20,000 bales. To that end, if all the 385,000 hectares would be used, by extrapolation, it means that revenue attained from cotton production would be approximately Kshs. 2.5 billion (KenInvest, 2016). Cotton production was on the decline despite the temporary recovery in the late 1980s (Figure 3). With the inception of the Structural Adjustment Policies (SAPs) between 1986 and 1994, there was deterioration of the vertical integrated systems for extension, input supplies and purchase of seed cotton. These, coupled with decreasing world prices, led to the abandonment of the crop by thousands of cotton growers.

Figure 3: Kenya cotton production 1960-2018 ('000 tons)



Source: (Adapted from KNBS Statistical abstracts)

1.1.2 Incentives to Increase Production and Government Strategy

The Kenyan government has put a considerable effort in favor of research and extension services despite the minimal allocation of resources towards the relevant institutions. Though the government is currently not offering subsidy to cotton growing, marketing and ginning aid or price support for producers, it is offering support to small holder farmers in form of planting seed, advisory service through research and extension services, supporting rehabilitation of irrigation schemes and focusing on the development of infrastructure (CODA, 2011). Revitalizing the cotton sub-sector requires provision for high yielding quality cotton varieties hence research has an indispensible task to play in ensuring sustainability as well as competitiveness of the cotton industry in the long run.

1.2 Statement of the problem

In 1984/1985, seed cotton attained its peak of national cotton production. However, in 1995 production decreased to 14,000 metric tons following liberalization of the subsector and disengagement of the government from giving subsidies and credits. Introduction of SAPs anticipated that the private sector would fill the niche and expand the markets. Practically, the private sector demonstrated to be highly risk averse to investing in enterprises related to small holder agriculture like cotton growing. Demand for cotton still supersedes its production and as such, the textile industry greatly relies on importation of cotton lint to satisfy its yearly demand. In the first 10 months of 2017, 26.8 billion Kenya shillings was spent to import textile products, an amount which was 20 percent more than the amount spent in the same period in 2016 (KNBS, 2017). Even with the sector's downturn in the current years, cotton is nonetheless one of the few cash crops that has the ability of expanding food security and employment opportunities through income generation in the Kenyan ASALs. Lately, cotton has received a lot of attention; it is anticipated to be amongst the big four benchmarks of the state's development blueprints that cover 2008-2030. Kenyan exports have preferential access to both regional and global markets. In addition, Kenya has duty free market entry to the European Union in the umbrella of the Economic Partnership Act (EPA) and to the United States of America (USA) under AGOA. The recent extension of AGOA by 10 years offers additional confidence for investment in Kenya. The potential that Kenya has for cotton through AGOA exports is a strong motivation to grow the industry. With the cotton industry leveraging on each and every opportunity that AGOA presents (that allows local apparel access to America duty free), cotton production in the country would increase. Despite the availability of such opportunities, cotton production has remained below the national demand. Therefore, the following question emerges, what then are the factors influencing the supply of cotton in Kenya? It is due to these reasons that the study sought to determine the factors that influence the supply of cotton in Kenya with the aim of proposing policy measures to improve production.

1.3 Study Objectives

1.3.1 General Objective

The general objective of the study was to examine the factors influencing the supply of cotton in Kenya**.**

1.3.2 Specific Objectives

i. To estimate the supply response of cotton in Kenya

ii. To draw conclusions and policy implication of the findings in (i) above for improving cotton production in Kenya

1.4 Significance of the study

As cotton importation outweighs its production, understanding the primary factors which influence its supply is of immense value for designing economic policies and their implementation in Kenya as well as attaining food security. A great concern in the revival of the cotton industry has transpired which to a greater degree has been triggered by the market opportunity offered the USA's African Growth Opportunity Act of 2000. An increase in cotton production through leveraging on AGOA will lead to exportation and further create a more favorable balance of payment (BoP) for the country.

Similarly, renewed effort to revive this labor-intensive sector is in line with the president's four-point agenda which seeks to lift economic contribution of manufacturing to 15 per cent, up from 9.2 per cent in 2016. Since the cotton industry has a long value chain, there will be employment creation for youth and women at every point along the value chain who form a bulk of the country's population.

Kenya's vision of becoming an industrialized country by 2030 is based on agro based industries. Reviving collapsed industries and attracting new investors to invest in modern cotton processing sector will offer opportunities of creating several industries like spinning, garment manufacturing, ginning, oil milling as well as animal feed among others.

The commercial importance of cotton emanates from its seeds that offer valuable oil for the food and chemical industries. Kenya's domestic vegetable oil production is below its national demand, making it the subsequent most imported good following petroleum. Therefore, this trend suggest that oil production offers an ideal market for domestic cotton seed which can be exploited to enlarge and further develop Kenya's cotton seed industry.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter covers the literature upon which the study was embedded. In particular, it covers in detail the theories upon which the study was anchored. Similarly, the chapter offers a detailed discussion on the empirical works in this area of study. The chapter concludes by giving a summary of the literature, pointing out the research gaps and the weaknesses of the existing works and how the present study sought to fill in the existing research gaps.

2.2 Theoretical literature review

Several studies have been undertaken on the supply response of agricultural commodities both in developed and developing countries. Literature review herein tackles issues relating to supply response, pricing, and the effect of producer prices on acreage and output.

The supply response approach was first adopted by Nerlove (1956; 1958) and eventually utilized by several other researchers. Nerlove suggested two models, the Adaptive Expectations model and the Partial Adjustment model. Nerlovian's adaptive expectation model is based on the behavioral hypothesis that farmers respond not to the previous year's price, but to the price they anticipate, and the anticipated price relies solely to a limited extent on what the previous year's price was (Nerlove, 1956). The model also postulates that hectarage under the crop in year t (H_t) is a linear function of the expected price in year t (p_t*). However, (p_t*) is not observable directly. Nerlove (1956) hypothesized further that every year farmers reviewed the price they anticipated to prevail in the forthcoming year in a proportion to the error they made in forecasting the price in the current period.

Nerlovian's partial adjustment model on the other hand bases its argument on the fact that farmers are always trying to bring the actual level of output to some desirable level; however, such efforts are never entirely successful, due to uncontrollable factors like weather fluctuations, technological constraints, persistence of habits or institutional rigidities (Nerlove, 1958).

The adaptive expectation model puts emphasis on the fact that uncertainty in prices is the reason for farmers' adjustments lags whereas the partial adjustment model specifies technological uncertainty as the reason for the lags. Johnston (1984) hypothesizes that there exist situations when both kinds of uncertainty arise and as such, the models pose difficulty in estimation. Krishna (1963) posits that it is simpler to estimate the partial adjustment model as compared to the adaptive expectation model.

While estimating the Nerlovian models, the current supply of a commodity is hypothesized to be affected by the supply of the same product in the previous period, its unit price, a competing enterprise's unit price, and other variables. The selection of other variables to include in a supply function is not obvious. A variable that is frequently added in the model is the trend variable. Normally, it is added to depict such factors like technological change, transport network improvement, and sufficient information which are not easily quantifiable. Nerlove and Addison (1958) posit that in the occasion that the coefficient of the trend variable is found to be statistically significant, it means the variables left out of the model are critical in explaining the variations in the dependent variable.

Meilink (1985) proposed that price was a very critical determinant of supply response. The scholar opined that prices paid by farmers for inputs were high to the extent that they affected the farmers' purchasing power. Findings from the study concluded that the right price incentives were a necessary but not a sufficient condition for attaining the required output mix.

The World Bank (1981) analyzed agricultural development in SSA and found out that agricultural production in the region had reduced as a result of extreme prominence of large scale government related schemes, improper investments, instructional frameworks as well as economic policies like pricing that were not favorable to increased production. According to the study, input supplies were too irregular, official prices were too low and marketing systems were uncompetitive.

In another study by World Bank (1984) on the analysis of the bottlenecks to agricultural production, results found that exchange rates, agricultural prices for export, and food commodities were crucial for agricultural development. Conclusion from the study indicated that incentives to farmers had declined as a result of changes in prices of inputs compared to prices of outputs as input prices rose more than the prices of export and food crops.

The World Bank (1985) assessed the marketing and pricing policies in Africa. Findings from the study revealed that in the second Structural Adjustment Lending (SAL) in Kenya, a greater concentration of the SAL included revamped pricing and marketing polices that saw the need to ensure sufficient incentives to producers. According to World Bank, the SAL did not automatically result in increased production as the supply response of a particular crop depended on its own price, price of the substitutes, price of inputs and technology. World Bank concluded that though the SAL led to ameliorated pricing and marketing polices, other factors also had to be ameliorated to have increased production.

The World Bank Sector report (1986) identified the incentive structure as the most crucial determinant of the supply of food commodities. The pricing policy was sought as the main limiting factors to production as domestic prices mirror import and export parity that are usually manipulated.

A study by De Wilde (1984) concurred with the World Bank's findings that poor performance was accredited to manipulated pricing and marketing policies. Also, various price intervention measures in SSA countries were used as fixed prices and subsidies that affected production. Conclusions from the study showed that famers were quite responsive to changes in prices.

2.3 Empirical Literature Review

This section reviews the empirical works with regards to the nexus of supply response of agricultural commodities.

Kere (1986) used cross-sectional data to assess the supply response of large scale wheat production in Nyandarua, Trans Nzoia, Nakuru, Uasin-Gishu, and Narok districts of Kenya between 1969 and 1983. The Nerlovian partial adjustment model was utilized to analyze the data by district. Results showed that the rainfall variable was negative but significant and the calculated price elasticities showed that farmers in all the districts except Narok had high positive response to annually announced prices of wheat.

Kenyanito (1991) investigated the reasons for the sluggish growth in annual seed cotton for Central and Eastern Kenya for the period 1965-1988. The scholar examined the trend in annual output, annual hectarage, cotton yield, nominal real and nominal prices of cotton. Similarly, hectarage of cotton was assumed to be a function of the previous hectarage, lagged producer price of a competing enterprise, lagged price, a trend variable and rainfall. The study adopted a linear form of the Nerlovian Partial Adjustment model. Findings from the study found that sluggish growth was due to a decline in the cotton yields.

Krishna (1963) assessed the price elasticity of supply for cotton, rice, maize, bajra, sugarcane, jowa, barley, wheat and gram in Pakistan and India. The study employed the Nerlovian Partial Adjustment model and hypothesized that yearly changes in cotton acreage were influenced by a trend variable, lagged acreage, annual rainfall levels, lagged relative prices of cotton, and lagged yield of cotton. Results of the study showed that annual rainfall levels significantly affected annual changes in cotton acreage in the dry regions of Punjab.

Narayana and Shah (1984) utilized Auto Regressive Integrated Moving Averages (ARIMA) estimations of yields and expected prices to study the acreage response of Kenyan farmers for the period 1957-1978. Findings from the study showed that levels of expected yield influenced the supply response of small farms. On the contrary, large farms responded strongly to output prices.

Abrar, Morrisey and Rayner (2004) assessed the responsiveness of peasant farmers to price and non-price factors in Ethiopia. Quadratic production function and restricted profit functions were determined by employing farm-level survey data from Ethiopia in 1994. Findings from the study indicated that own- price output supply elasticity was quite low and output supply was not responsive to fertilizer prices or wage rate. The study revealed that non-price factors were critical in affecting production compared to price incentives. Further, the authors stressed on the need to reinforce market impetus through adequate frameworks which boosts farmers reach to land, credit, fertilizer, irrigation, and public investment in roads.

Gunawardana and Oczkowski (1992) undertook a study on the comprehensive analysis of supply response in the paddy rice sector of Sri Lanka for the period 1952-87 to assess the impact of pricing policy, yield, irrigation programs, permitted sales on area, institutional credit in addition to the general supply. The focus of the approximation technique was the identification of an ideal functional form for regression and a price variable which represented the price that producers react to in making decisions regarding yield and area. Findings from the study showed that institutional credit, irrigation programs and pricing policy offered incentives to the extension of paddy production while permitted sales of rice was a restraint.

Hag Elamin and El Mak (1997) undertook a comparative study to assess the effect of the primary SAPs by the Sudanese government on agricultural price incentives for the period 1978-1993. The impact of the programs on the stability and level of price stimulus were gauged. Findings from the study showed that the SAPs failed to ameliorate the stability and level of real farm prices. Also, a rise in real farm prices had a positive but finite universal impact on agriculture and non-price factors played a huge task in finding cumulative output. The study concluded that in the absence of supply of sufficient public investment, credit and amelioration in infrastructure, adequate response of agriculture to price stimulus would be low.

Behrman (1968) examined the supply response of four annual crops in Thailand for the period 1937-1963 using a modified Nerlovian model. The scholar hypothesized that the desired planted area in any given period was a function of the expected harvested production, actual harvested area, the farms population, actual price, and the annual malarial death rate. Findings from the study showed that farmers in economically underdeveloped countries responded appropriately to economic incentives. Behrman's study deviated from other studies by attempting to capture the effect of variables like death rate from malaria and the variable population and disregarded the likelihood of the effect of inputs of competition from other crops and weather.

Mythili (2006) estimated the supply response for major crops (cotton, rice, wheat, jowar, bajra, sugarcane, rapeseed, mustard, groundnuts and grams) to price incentive in India during the pre and post reform periods using the Nerlovian model with panel data for the period 1970-71 to 1999-2000. Yield and acreage response functions were estimated. Irrigation variable was not included in the study due to insufficient time series data. The study did not find any significant difference in supply elasticities between pre and post reform periods for most of the crops. What is more, the study rejected the argument that market liberalization had improved output response to price incentives. Results also indicated that farmers react to price stimulus equally more by use of non-land inputs.

Koo (1982) undertook an econometric investigation of the U.S wheat acreage response to market prices using the Nerlovian geometric lag model for the period 1961 to 1980. The study found out that the elasticity for wheat price in winter was more inelastic as compared to the spring season. Explanation for the aforementioned occurrence was that during the spring season, there was a probability of replacing wheat production with other crops whereas in winter replacement was limited in the wheat producing region.

Maitha (1974) assessed wheat and maize production response with reference to price using data on large farms for the period 1954-1969. The study used the Nerlovian model to estimate the acreage of wheat and maize separately. Maize and wheat were handled as mutually competing commodities. The study failed to check the possibility of auto correlation. Findings from the study showed that Kenyan farmers react to changes in price. Also, price elasticity was greater for maize than wheat.

Mugweru (2011) used the Nerlovian model to estimate the supply response of coffee to price as well as non price factors in Kenya using secondary time series data for the period 1970-2008. Findings from the study showed that there was a positive relationship between price and output of coffee. There was a positive and significant relationship with hectarage planted and price of input (fertilizer) and output. There was a negative and insignificant relationship between output of coffee and rainfall. Also, the relationship between output of coffee and credit advanced was negative but statistically significant. The study recommended that the government needed to intervene by addressing the credit constraints faced by farmers.

Mfumu (2013) assessed the supply response of the cashew nut industry under market reforms in Tanzania using secondary time series data for the period 1991-2012 using the ARDL bounds test approach. Results indicated that the supply of cashew nut was elastic in the short run to price and non-price factors. However, the study failed to estimate long run elasticities due to lack of evidence to support the presence of cointegration.

Kabubo (1991) investigated the factors influencing the supply of wheat in Kenya using secondary time series data for the period 1970-1989 and employed a modified form of the Nerlovian supply response model. Finding from the study showed that amount of rainfall, SAPs, and relative price were significant factors influencing output of wheat. Hectarage planted in the previous period, relative prices and SAPs were found to be significant in influencing hectarage planted to wheat. Price indices of fertilizer, hectarage planted in a given period, and the time trend variable were found to be insignificant in influencing output of wheat.

Moses (2015) assessed the tea supply response in Kenya using time series data for the period 1990-2014 and employed the dynamic Nerlovian model. The variables that the study used were tea prices, tea supply, input prices, real exchange rate, price of milk, wage rate, and dummy variable representing weather pattern. Findings from the study showed that there was a positive and significant relationship between the current quantities of tea supplied and the previous tea prices and wage rate. Previous input prices had a negative influence to the quantity of tea produced. The study also revealed that real exchange rate had a significant and negative relationship with tea supply in Kenya.

2.4 Overview of Literature Review

Observation from the theoretical literature review is that despite the sound argument they offer most of the arguments were not based on econometric empirical investigation. To that end, it is of essence not to rely strongly on the findings and draw general conclusions. The arguments should be tested to seek and prove their validity.

Various scholars employed different approaches trying to model the response of agricultural commodities to price and non-price incentives alike. There was a great variation with regards to methodological approach to the issue clearly showing the view that no single approach acquired a general acceptance among scholars. Each approach is appropriate depending on the situation and the desirable interest under investigation. In modeling agricultural response, the Nerlovian approach seemed to have dominated earlier from the late 1950s to 1980s. Findings may be identical in various areas or nations but the explanation behind such findings seem to differ significantly across the regions. Despite the approaches employed, all the studies reviewed considered pricing policy as the main variable factor in their analysis. There was a considerable disparity when it came to choosing the non-price factor to be included. Government expenditure on research is a variable that was not critically analyzed by the previous studies. Therefore, this study introduced government expenditure on research variable and examined how it affected both output of cotton and hectarage planted to cotton.

CHAPTER THREE

METHODOLOGY

3.1 Theoretical framework

Nerlove (1956) particularized both an expectational and an adjusted lag model for acreage and output determination. The model has been appraised as one of the most sort for model when measuring the agricultural supply response. It is dynamic and posits that output is a function of expected price, output adjustment and exogenous variables. The model is specified as follows:

$X_t^* = a_0 + a_1 P_t^* + \mu_t$ (1)

$P_t^* = \beta P_{t-1} + (1-\beta) P_{t-1}^*$ $0<\beta\leq 1$ (2)

$X_t - X_{t-1} = \lambda(X_t^* - X_{t-1})$ $0<\lambda\leq 1$ (3)

Where:

X_t^* = Desired hectarage at time t

X_t =Actual hectarage at time t

P_t^*= Expected price at time t

P_t = Actual real producer price at time t

β = coefficient of expectation

λ = adjustment coefficient

μ_t = a random residual

In situations where there is no advancement in technology, then the expected output is equal to the actual output.

Re-writing equations 2 and 3 we get:

$P_t^* - P_{t-1}^* = \beta(P_{t-1} - P_{t-1}^*)$………………………………………………… (4)

$X_t^* = \frac{1}{\lambda}(X_t) - \frac{(1-\lambda)}{\lambda} X_{t-1}$…………………………………………………………… (5)

Equations (4) and (5) are differential equations in P_t^* and X_t^* respectively

Thus a non-iterative procedure of estimation is used in equation 1, 2 and 3 to obtain equation 6:

$$X_t = \alpha_0 B\lambda + \alpha_1 B\lambda P_{t-1} + [1 - B + 1 - \lambda]X_{t-1} - (1 - B)(1 - \lambda)X_{t-2} + \lambda[\mu_t - (1 - B)\mu_{t-1}] \ldots\ldots (6)$$

When we transform equation 6, we get the regression form of the equation as below;

$$X_t = \delta_0 + \delta_1 P_{t-1} + \delta_2 X_{t-1} + \delta_3 X_{t-2} + \mu_t \ldots\ldots (7)$$

Challenges would be experienced when it comes to estimating the model above due to the fact that it is a combination of both expectational and adjustment lag variables. Therefore, it becomes difficult to specify a separate coefficient for each. So, it is necessary to select a model that provides for an adjustment lag model only or a model that favors the expectation lags (Krishna, 1963).

3.2 Empirical Model Specification

This study used a modified version of the Nerlovian formulation. The model is modified to cater for the shortcomings of the original model. The adjustment lag model is the best workable option in as much as it oversimplifies expectation behavior. Due to this, several researchers like Kabubo (1991), Zaki (1976) and Jhala (1979) adopted a modified version of the Nerlovian adjustment lag model to estimate the supply responsiveness of wheat, groundnut and cotton in Kenya, India and Egypt respectively.

Taking the Nerlovian adjustment hypothesis into consideration, an assumption is made that the change in actual output Q_t from the previously existing level Q_{t-1} is merely some fraction of the change needed to attain the equilibrium level Q_t (Kabubo, 1991).

Suppose the proportion attained is β then we can show this in the form:

$$\ln Q_t - \ln Q_{t-1} = \beta(\ln Q_t - \ln Q_{t-1}) \ldots\ldots (8)$$

Then we simplify equation (8) to get the like terms and include the other exogenous non price variables that influence the quantity of cotton produced, to get the output equation below:

$$\ln Q_t = d_0 + d_1 \ln P_t + d_2 \ln A_t + d_3 \ln Z_t - \delta_4 \mathrm{W}_t - \delta_5 SAP + d_6 \ln RD + d_7 \ln T + \mu_t \quad (9)$$

Where:

Q_t = Actual output

P_t = Price ratio of cotton and a competing alternative crop (maize)

A_t = Hectarage planted to cotton

W_t = Rainfall incorporated as a dummy variable (Durations of optimal rainfall take a value of 0, otherwise 1)

SAP_t = Dummy for structural adjustment programs: 1=1995 onwards and 0=1986-1994.This represents a change in the institutional environment

RD_t =Government expenditure on research

T = Time trend variable.

Z_t- Price of inputs

μ= Error term

The hectarage model is obtained following the same specification as in the output model.

The model estimated is:

$$\ln A_t = b_0 + b_1 \ln P_t + b_2 \ln A_{t-1} + b_3 \ln Y_{t-1} - b_4 SAP + b_5 \ln T + b_6 \ln RD - b_7 \mathrm{W}_t + +\mu_t \quad (10)$$

Where:

A_t = Hectarage planted in the present period.

A_{t-1} = Hectarage planted in the previous period.

P_t = Relative cotton maize price ratio

Y_{t-1} = Yield of cotton in the previous period

RD_t=Government expenditure on research

T = Time trend variable

SAP_t = Dummy for structural adjustment programs: 0=1995 onwards and 1=1986-1994.This represents a change in the institutional environment.

W_t = Rainfall incorporated as a dummy variable (Durations of optimal rainfall take a value of 0, otherwise 1)

Ordinary Least Square (OLS) method was used to run the regression model.

Table 1: Description and measurement of output and hectarage variables

Variable		**Description/Measurement**	**Expected sign**
Dependent Variable			
Output		Total production/ tonnage produced	
Hectarage planted		The coverage of the land under cotton in Kenya	
Independent Variables			
Relative Price		Price ratio of cotton and maize	+ (Positive)
Hectarage planted		The coverage of the land under cotton in Kenya	+ (Positive)
Rainfall		Rainfall incorporated as a dummy variable (Durations of optimal rainfall take a value of 0, otherwise 1)	(Indeterminate)
Yield		Returns per hectare; (= production data (output)/ the data on area harvested (hectarage planted)	+ (Positive)
Price of inputs		The price indices for pesticides were taken as a proxy for the input prices. The less the input, the lower the output.	- (Negative)
Time trend (T)		Captures the effect of long run structural changes in equilibrium output over time. Consequently, it is a variable for technological change	Indeterminate
SAP		A dummy variable equal to 0 for 1995 onwards and 1= 1986-1994. This represents a change in the institutional environment	Indeterminate
Government expenditure on research and		Annual amount in KSH spent on research	+ (Positive)

3.3 Data Types and Sources

The study used quantitative secondary time series data. Annual data for the 1960-2018 was used for analysis. Main data sources were economic surveys and statistical abstracts. Data on cotton, maize nominal producer price, government expenditure on research and area under cotton were acquired from statistical abstracts. Yearly data on cotton and maize production as well as price indices of pesticides were obtained from economic surveys and statistical abstracts while rainfall data was acquired from the Department of Meteorological Services (DMS) as well as from statistical abstracts.

3.4 Diagnostic Testing

3.4.1 Pre estimation tests

Unit Root Tests

Since the study used time series data for the period under study, there was need to conduct some diagnostic test associated with times series data to ensure that the coefficients obtained are valid. Times series data is stationary or has a unit root if its mean, variance and auto covariance remain constant throughout the time series. The Augmented Dickey-Fuller (ADF) tests the univariate time series data for the presence of unit roots or non-stationarity. To check for stationarity of the data used in analysis the study adopted the unit root test. This ensures that variables are used at the level where they are stationary; data is required to be stationary as non-stationary data would often lead to spurious regression estimates and inconsistent coefficients that arises when the variables of the model have different orders of integration.

Cointegration test

Cointegration test was conducted to determine whether the variables move in the same direction in the long run. Engle-Granger Test was used to test for cointegration among the variables in the model.

3.4.2 Post estimation diagnostic tests

Normality test

For the validity of hypothesis testing, the assumption of normality assures that the p-values for the F-test and T-test are valid. The study used the Skewness-Kurtosis test to verify whether the residual was normally distributed or not.

Multicollinearity test

Multicollinearity occurs when there is high correlation between two or more explanatory variables. This occurrence creates redundant information that ultimately skews regression results. To detect the problem of multicollinearity, the paper used the variance inflation factor. A variable who's VIF is greater than 10 depicts the presence of multicollinearity.

Auto Correlation test

Autocorrelation means correlation of time series with its past and future values. Breusch – Godfrey LM test was used to test for autocorrelation.

Functional form

Ramseys RESET test was used to determine whether there exists significant non linear relationship in the suggested linear model.

Heteroscedasticity test

The presumption of homoscedasticity is that the variance of the errors is constant and finite over time. The study used the Breusch-Pagan-Godfrey Test to test whether the error terms were correlated across observation in the data.

CHAPTER FOUR

EMPIRICAL RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the data analysis procedure, the empirical results and the discussion ensuing from the analysis. In particular, this chapter discusses in detail the summary statistics, diagnostic tests that were conducted, and the regression estimates obtained.

4.2 Summary statistics

Table 4.1 below shows the summary statistics of the variables used in the study. The mean of output was 5.86 (‘000Metric Tons), the mean of rainfall (dummy) was 0.21, the mean of relative price was 2.37 (Sh. Per 100 kg), hectarage planted had a mean of 55.74 (‘000Hectares), yield had a mean of 119.30 (KG/HA), the mean of input price was 456,986 (000K£) while SAPS (dummy) had a mean of 0.16 and finally government expenditure on research had a mean of 237,251('000K£).

Table 4.1: Summary statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
output '000MT	58	5.86	2.40	1.74	13.50
Rainfall dummy	58	0.21	0.41	0.00	1.00
Relative Price (Sh. per 100 kg)	57	2.37	0.87	0.33	4.07
Hectarage Planted ('000 HA)	58	55.74	25.94	21.00	145.00
Yield (KG/HA)	58	119.30	56.15	32.00	303.00
Price of inputs '000K£	50	456,986	1,020,000	313	3,625,000
Dummy SAPS	58	0.16	0.37	0.00	1.00
Gvt Expenditure on Research '000K£	50	237,251	438,624	857	1,851,000

Results from the correlation matrix presented in table 4.2 below indicate that rainfall, price of inputs, SAPs and government expenditure on research related negatively to output of cotton. Relative price and hectarage planted to cotton related positively to output of cotton.

Price of inputs, SAPs, rainfall and government expenditure on research all related negatively to hectarage planted to cotton. Relative price related positively to hectarage planted to cotton.

Table 4.2: Correlation matrix

	output '000MT	Rainfall dummy	Relative Price (Sh. per 100 kg)	Hectarage Planted ('000 HA)	Yield (KG/HA)	Price of inputs '000K£	Dummy SAPS	Gvt Expenditure on Research '000K£
output '000MT	1							
Rainfall dummy	-0.23	1						
Relative Price (Sh. per 100 kg)	0.20	0.042	1					
Hectarage Planted ('000 HA)	0.44	-0.036	0.48	1				
Yield (KG/HA)	0.42	-0.159	-0.31	-0.55	1			
Price of inputs '000K£	-0.05	0.037	-0.38	-0.40	0.48	1		
Dummy SAPS	-0.12	-0.101	0.12	-0.06	-0.13	-0.21	1	
Gvt Expenditure on Research '000K£	-0.13	0.068	-0.54	-0.47	0.49	0.93	-0.25	1

4.3 Diagnostics Tests

Before running the regression model, the study performed econometric tests that must be conformed to when running regression analysis.

4.3.1 Unit Root Test

As a norm, unit root test was conducted to check for stationarity of the data used in analysis. This ensures that variables are used at the level where they are stationary; the data is required to be stationary as non-stationary data would often lead to spurious regression estimates. The study conducted unit root test by adopting the Augmented Dickey-Fuller (ADF) test. The results of the unit root test indicate that all the variables were non-stationary at the 5% significance level as shown in table 4.3 and thus were differenced once to stationarize them.

Table 4.3: Unit Root Tests at Level

Variable		No Trend		Trend		
	Optimal Lag length	**Test Statistic**	**5% Critical Value**	**Test Statistic**	**5% Critical Value**	**Decision Rule**
Output	1	-3.012	-2.925	-2.888	-3.494	Non-stationary
Relative Price	1	-2.313	-2.926	-3.592	-3.495	Non-stationary
Hectarage Planted	1	-1.943	-2.925	-2.313	-3.494	Non-stationary
Yield	2	-2.770	-2.926	-3.559	-3.495	Non-stationary
Price of inputs	1	0.202	-2.936	-1.418	-3.508	Non-stationary
Gvt Expenditure on Research	1	0.117	-2.936	-2.042	-3.508	Non-stationary

Upon first differencing, the variables became stationary as indicated by the results in Table 4.4 below. After the variables had been tested for stationarity, they were modeled at first difference as they were stationary at this level.

Table 4.4: Unit Root Tests after First Difference

Variable		No Trend		Trend		
	Optimal Lag length	**Test Statistic**	**5% Critical Value**	**Test Statistic**	**5% Critical Value**	**Decision Rule**
Output	1	-5.986	-2.926	-5.985	-3.495	Stationary
Relative Price	3	-4.833	-2.928	-4.883	-3.498	Stationary
Hectarage Planted	0	-7.737	-2.925	-7.692	-3.494	Stationary
Yield (KG/HA)	1	-5.456	-2.926	-5.403	-3.495	Stationary
Price of inputs	0	-7.391	-2.936	-7.426	-3.508	Stationary
Gvt Expenditure on Research	0	-7.020	-2.936	-7.034	-3.508	Stationary

4.3.2 Test for Co-Integration

After ascertaining the stationarity properties of the series, it is essential for co-integration analysis to be done. The first step entails generating the residuals from the long run equation of the non-stationary variables. Then stationarity of the residual was tested using the Engle-Granger Test. Results are presented in table 4.5 below. From the results, the null hypothesis that co-integration exists fails to be rejected. Meaning, in the long run, all the variables in the output and the hectarage model converge to equilibrium.

Table 4.5: Co-integration: Engle-Granger Test

Variable: Residual	**Test Statistic**	**5% Critical Value**	**Decision Rule**	**Conclusion**
Output Model	-4.388	-2.941	Stationary	Cointegration exists
Hectarage Model	-6.474	-2.933	Stationary	Cointegration exists

4.4 Regression Results

Long run regression results of both the output model and the hectarage model are presented in table 4.6 below

Table 4.6: Long-run regression models

	(1) Output Model with natural logarithm of output as the dependent variable	(2) Hectarage Model with natural logarithm of hectarage planted as the dependent variable
Constant	0.567	0.0776
	(0.580)	(1.016)
Relative Price	-0.0132	0.212
	(0.173)	(0.153)
Hectarage Planted	0.368***	
	(0.0982)	
Rainfalldummy	-0.111	-0.125
	(0.105)	(0.107)
Dummy SAPs	-0.128	-0.0840
	(0.0976)	(0.0947)
Government Expenditure on Research	-0.212***	-0.00812
	(0.0735)	(0.0254)
Price of inputs	0.200***	
	(0.0546)	
Lag of Hectarage Planted		0.818***
		(0.120)
Lag of Yield		0.120
		(0.129)
N	50	50
R^2	0.482	0.737
adj. R^2	0.409	0.700

Standard errors in parentheses
$^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.01$

Therefore;

The Output model is as follows:

$$\begin{aligned}\ln Q_t \; &= 0.567 - 0.0132 \ln \text{RelativePrice} + 0.368 \ln \text{HectaragePlanted} \\ &\quad - 0.111\text{DummyRainfall} - 0.128\text{DummySAPs} \\ &\quad - \; 0.212 \; \ln \text{GovernmentExpeResearch} + 0.2 \ln \text{PriceOfInputs}\end{aligned}$$

Findings from the study depict that the overall goodness of fit of the output model, as reflected by R-squared, is 0.482. This shows that 48% of the variations in cotton output are explained by variables in the model. Table 4.6 above depicts the results that aid in determining the significant variables in the model.

From the study it is evident that there exists a positive relationship between hectarage planted to cotton and output as shown by a coefficient of 0.368. Further, the relationship is statistically significant at the 10% level of significance. The study therefore concludes that hectarage planted to cotton is a crucial factor in influencing the supply of cotton. As was stated in the introduction section, Kenya has 385,000 hectares of land favorable for cotton cultivation but barely a fraction of it is under production. Currently, cotton is cultivated solely on 25,000 hectares and is valued at approximately Kshs.179 million. If all the 385,000 hectares would be used, by extrapolation, it means that revenue attained from cotton production would be approximately Kshs. 2.5 billion.

There exists a negative relationship between output of cotton and rainfall (dummy). This is evidenced by the coefficient of -0.111. This implies that a decrease or increase in rainfall beyond the optimal level of would result in a drop in the output of cotton. However, the relationship is statistically insignificant at all levels of significance.

There is a positive and statistically significant relationship between output of cotton and input price (pesticide). This is depicted by the coefficient value of 0.200 at the 1% level of significance. Implying that input price is a critical factor in influencing the supply of cotton.

There is a negative and significant relationship between output of cotton and government expenditure on research. The coefficient of the government expenditure variable on research is -0.212 and is significant at the 1% level of significance. This coefficient deviates from coefficient which was anticipated. Ideally, the research agenda for cotton in Kenya has been low keyed. Also, publicly funded research in cotton is weak yet research plays a fundamental role in ensuring the sectors sustainability and competitiveness in the global scene as well as in the long run.

There exists a negative relationship between output of cotton and SAP as indicated by the coefficient of -0.128. However, the variable SAP is insignificant at all levels. These findings are similar to those of Mythili (2006) who disputed the argument that market liberalization had improved output.

There exists a negative relationship between output of cotton and the relative price as indicated by a coefficient of -0.0132. Meaning, the relative price is not favorable for cotton producers. To make it more favorable, there is need to review the annual prices of cotton to ensure that they concur with import parity prices. Nonetheless, the variable is insignificant at all levels of significance.

The hectarage model is as follows:

$$
\begin{aligned}
\ln \mathrm{A_t} = {} & 0.0776 + 0.212 \ln \mathrm{RelativePrice} - 0.125\mathrm{DummyRainfall} - 0.0840\mathrm{DummySAP} \\
& - 0.00812 \ln \mathrm{GovExpResearch} + 0.818 \ln \mathrm{HectaragePrevious} + 0.12 \ln \mathrm{Yield}
\end{aligned}
$$

Findings from the study depict that the overall goodness of fit of the hectarage model, as reflected by R-squared, is 0.737. Meaning, 74% of the variations in cotton hectarage are explained by variables in the model. Table 4.6 above depicts the results that aid in determining the significant and non significant variables in the hectarage model.

Findings from the study indicate a clear positive relationship between relative price and hectarage planted to cotton as indicated by a coefficient of 0.212. However, the variable is insignificant at all levels.

The variable yield has a coefficient of 0.120. It has the expected positive sign. However, it is insignificant at all levels.

There is a negative relationship between hectarage planted to cotton and SAPs as indicated by the coefficient of -0.0840. The variable SAPs is also not significant at all levels.

There exists a negative relationship between hectarage planted to cotton and rainfall as shown by the coefficient of -0.125. The variable is however not significant at all levels of significance.

There is a positive relationship between the current hectarage planted to cotton and the previous hectarage planted to cotton as indicated by a coefficient of 0.818. The variable is also significant at the 1% level of significance. We can therefore conclude that hectarage planted to cotton in the previous period is a critical factor in influencing hectarage planted to cotton in the present period.

There exists a negative relationship between hectarage planted to cotton and rainfall (dummy). This is evidenced by the coefficient of -0.125. A decrease or increase in rainfall beyond the optimal level of would result in a drop in the hectarage planted to cotton. However, it is not significant at all levels.

4.5 Error Correction Model

Since the variables were established to be co integrated, the short-run error correction model was estimated to link the short run and long run relationships. The estimates of the error-correction model are presented in Table 4.7 below:

Table 4.7: Short-run error correction models

	(1) Output Model with first difference of the natural logarithm of output as the dependent variable	(2) Hectarage Model with first difference of the natural logarithm of hectarage planted as the dependent variable
Constant	0.0208	0.00292
	(0.0448)	(0.0462)
D.Relative Price	0.184	0.165
	(0.164)	(0.165)
D. Hectarage Planted	0.394**	
	(0.149)	
LD. Hectarage Planted		0.722**
		(0.327)
Rainfall dummy	0.00726	-0.124
	(0.113)	(0.117)
Dummy SAPs	-0.0395	-0.0210
	(0.0953)	(0.0979)
D. Government Expenditure on Research	-0.304**	0.0580
	(0.114)	(0.0848)
D. Price of inputs	0.243**	
	(0.0942)	
Error Correction Term (ECT)	-0.595***	-0.836**

	(0.157)	(0.348)
LD. yield		0.152
		(0.127)
N	49	49
R^2	0.455	0.202
adj. R^2	0.362	0.066

Standard errors in parentheses
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

The Output model

Findings from the study depict that the R-squared of the output model is 0.455. Meaning, 45.5% of the variations in cotton production are explained by the explanatory variables in the model. The variables that were found to have a positive and significant relationship to output of cotton in the short run were hectarage planted (coefficient of 0.394 and $p < 0.05$) and price of inputs (coefficient of 0.243 and $p < 0.05$). The only variable that was found to have a negative and significant relationship to output of cotton in the short run was government expenditure on research (coefficient of -0.304 and $p < 0.05$).

The Hectarage model

Findings from the study depict that R-squared of the hectarage model is 0.202. Meaning, 20.2% of the variations in hectarage planted to cotton are explained by the explanatory variables in the model. The only variable found to have a positive and significant relationship to hectarage planted to cotton in the short run was hectarage planted in the previous period (coefficient of 0.722 and $p < 0.05$). In the hectarage model, the error correction term was negative (-0.836) and statistically significant at the 5% level. Meaning, there is a convergence to the long run equilibrium. The coefficient of (-0.836) shows that 83.6% of the disequilibria in hectarage planted to cotton attained in one period are corrected in the subsequent period.

Post diagnostic tests

4.3.3 Test for Multicollinearity

Regression analysis requires that variables should not be correlated. To test for this assumption the study adopted the Variance Inflation Factors (VIF). Multicollinearity is considered a concern when the Variance inflation factors are in excess of 10 or the tolerance levels (usually the reciprocal of the variance inflation factors values) are less than 0.10. Table 4.8 below shows that the Variance inflation factors for all the variables used in the model are less than 10 and it was thus concluded that the variables are not correlated or multicollinear.

Table 4.8: Test for Multicollinearity: Variance Inflation Factors

Variable	VIF	1/VIF
Government Expenditure on Research	3.28	0.305274
Relative prices	2.87	0.348016
Yield	2.35	0.424676
Hectarage Planted	2.31	0.432201
Rainfall Dummy	1.11	0.901164
Dummy SAPs	1.06	0.940858
Mean VIF	2.17	

4.3.4 Test for Normality

Normality in data is a condition where the data is free from outliers or extreme variables. A normality test therefore checks whether the distribution of the data obeys the normality assumption. Regression analysis requires normal data since the standard errors and regression coefficients calculation require the use of a mean. For this study normality tests was carried out using the Skewness-Kurtosis test as indicated in table 4.9 below. The null hypothesis of normal distribution was not rejected at the critical 5% significance level as the reported probabilities of both the output and hectarage model are greater than 5%.

Table 4.9: Skewness-Kurtosis test for Normality

	N	Pr(Skewness)	Pr(Kurtosis)	adj χ^2	P − value
Residual of output model	50	0.2910	0.8958	0.89	0.5892
Residual of hectarage model	50	0.3412	0.9713	0.94	0.6244

4.3.5 Test for Heteroscedasticity

Heteroscedasticity test was run in order to test whether the error terms were correlated across observation in the data using Breusch-Pagan-Godfrey Test. The null hypothesis is that the data is homoskedatic (that is, constant variance). The null hypothesis of homoscedasticity was therefore not rejected at the critical 5% significance level as the reported probability associated with the test in both output and hectarage are greater than 5% as indicated in the Table 4.10 below. It was thus concluded that the residuals are homoskedastic.

Table 4.10: Heteroskedasticity Test: Breusch-Pagan/Cook-Weisberg test for heteroskedasticity

Model	$\chi^2(1)$	P-value
Output Model	0.60	0.4375
Hectarage Model	0.11	0.7447

4.3.6 Test for Functional Specification of the Model

The study also tested for functional (mis-) specification using the Ramsey Reset test. The null hypothesis of the test states the correct specification is linear versus the alternative hypothesis that states that the correct specification is non-linear in form. The results of the test are presented in Table 4.11 below and it can be established that the null hypothesis is not rejected as the Ramsey Reset F-statistics have p-values which are in excess of the critical 5% significance level and thus the study does not reject the null hypothesis that the functional form of the model is correctly specified.

Table 4.11: Ramsey RESET Test

Model	F-Test	P-value
Long-run Output Model	$F(3,40) = 1.20$	0.3219
Long-run Hectarage Model	$F(3,38) = 0.44$	0.7279
Short-run Output Model	$F(3,40) = 0.96$	0.4230
Short-run Hectarage Model	$F(3,40) = 4.47$	0.0880

4.3.7 Test for Autocorrelation

The study checked for autocorrelation using the Breusch –Godfrey LM test, where the null hypothesis under the test states that there is no serial/autocorrelation. The results presented in the Table 4.12 below shows that the probability value associated with the test is greater than the critical 5% significance level and thus it was concluded that the residuals do not suffer from serial correlation/autocorrelation both in the output and hectarage model.

Table 4.12: Breusch-Godfrey LM test for autocorrelation

	Lags(p)	χ^2	df	$\mathrm{P-value}$
Output model	1	6.121	1	0.2134
Hectarage model	1	0.250	1	0.6173

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the study findings and results, and further presents the conclusions and recommendations based on the findings of the study.

5.2 Summary

This study attempted to investigate the factors influencing the supply of cotton in Kenya by estimating two models; the output model and hectarage model. Further, the study aimed at proposing policy recommendations based on the findings of the study. First, the study determined the stationarity of the variables and found that all the variables were non stationary at levels, but after first differencing, the series became stationary.

The study used the modified Nerlovian supply response model to estimate both the output and hectarage model. The output model had relative price, hectarage planted to cotton, rainfall (dummy), SAPs (dummy), price of inputs and government expenditure on research as the independent variables. The hectarage model on the other hand had hectarage planted in the previous period, yield of cotton in the previous period, SAPs (dummy), rainfall (dummy), relative price and government expenditure on research as the independent variables.

In the long run, the output model had an R Squared value of 40% indicating that there are some variables that capture the changes in output and play a critical role, but were not included in the model. The positive and significant factors in influencing output of cotton were found to be price of inputs, which, based on literature is true because the less the input, the lower the output. Also, pest control alone (proxy for input) takes between 30% and 40% of the production costs for cotton. Hectarage planted to cotton was also positive and significant in influencing output of cotton. Government expenditure on research was found to be negative though significant in influencing output of cotton.

The hectarage model had an R Squared value of 73.7 which was satisfactory. Hectarage planted to cotton in the previous period was the only variable found to be positive and significant in influencing hectarage planted to cotton in the present period. Rainfall (dummy), SAPs (dummy) and government expenditure on research were found to be negative and insignificant in influencing hectarage planted to cotton. Relative price was positive and insignificant in explaining hectarage planted to cotton.

Based on the Error-correction model estimation, in the short run, hectarage planted to cotton had a positive and significant relationship with output of cotton. Government expenditure on research had a negative and significant relationship with output of cotton. In the short run, only hectarage planted in the previous period was found to have a positive and significant relationship with hectarage planted to cotton in the present period. Further, findings from the study depicted a negative (-0.595) and significant ($p< 0.01$) error correction term in the output model. Also, there was a negative (-0.836) and significant ($p< 0.05$) error correction term in the hectarage model.

5.2 Conclusion and Policy Recommendations

Based on the above findings, the study concluded that there was a positive and significant relationship between output and hectarage planted to cotton, a negative and significant relationship between output and government expenditure on research, a negative and significant relationship between output and price of inputs. The negative relationship between output of cotton and government expenditure on research is because the research agenda for cotton in Kenya has been low keyed. Also, publicly funded research in cotton is weak yet research plays a fundamental role in ensuring the sectors sustainability and competitiveness in the global scene as well as in the long run. This means that it is of essence to strengthen the linkages between cotton output and research and adequate funds should be allocated in favor of research in cotton.

From the (Hectarage Model), the study concluded that only hectarage planted to cotton in the previous period was found to be positive and significant in influencing the hectarage planted to cotton in the present period.

In general, it is evident that government expenditure on research, price of inputs, hectarage planted in the present period and hectarage planted in the previous period are the factors influencing cotton output and hectarage planted to cotton in Kenya.

Given that the aforementioned factors are crucial in influencing cotton production in Kenya, the government should put stringent measures using these factors in deriving policies aimed at ameliorating cotton production in Kenya. In particular, the government should introduce subsidies that lower the input costs as this cost takes a huge chunk of production costs. This will encourage cotton producers to increase their production. Farmers are encouraged to make use of all the available 385,000 hectares that is viable for production. Also, it is of essence to strengthen the linkages between cotton output and research and adequate funds should be allocated to research in cotton. This would see to it that farmers benefit from research findings and increase production. What is more, the greater public sector should participate in technology transfer. This call for the need of setting up a body that has in place elaborate incentive mechanisms across the cotton value chain to enhance local and foreign investment through leveraging on Public Private Partnerships (PPPs).

5.4 Areas for further study

In order to enjoy economies of scale, access to affordable credit is essential. Several commercial entities are reluctant in lending credit to cotton producers and if given, then it is accompanied by delays in loan processing that result in late farm operations. To that end, it is of essence to investigate what credit advanced to cotton producers would have on both output and hectarage planted to cotton.

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APPENDICES

Appendix 1: Data

Year	Rainfalldummy	RelativePrice(Sh. per 100 kg)	Hectarage Planted ('000 HA)	yield(KG/HA)	Priceinputs '000K£	DummySAPS	GvtExpend Research '000K£
1960	0	2.691667	38	74		0	
1961	0	2.901152	55	32		0	
1962	1	0.325399	51	60		0	
1963	1	3.288672	55	55		0	
1964	1	2.98425	55	59		0	
1965	0	2.927104	55	79		0	
1966	1	2.370851	71	61		0	
1967	1	2.694271	71	55	313	0	1265
1968	1	3.181818	26	159	351	0	905
1969	0	3.181818	30	167	435	0	857
1970	0	3.606545	26	209	531	0	1028
1971	0	3.143414	34	154	588	0	1181
1972	0	2.968887	52	105	773	0	1848
1973	0	3.125482	52	100	786	0	1788
1974	0	3.345036	69	79	1134	0	1879
1975	0	2.723145	71	77	1278	0	2016
1976	0	2.72332	75	73	1470	0	2258
1977	1	3.242884	85	90	1762	0	2360
1978	1	4.069963	105	97	2329	0	2828
1979	0	3.691529	115	117	2798	0	3180
1980	0	3.473105	110	79	3247	0	2624
1981	0	3.4087	110	71	2836	0	2703
1982	0	3.266568	105	75	3421	0	2919
1983	0	2.474269	145	38	993	0	3065
1984	0	2.56	97	135	4372	0	3126
1985	0	2.566845	68	134	4754	0	3281
1986	0	2.37373	50	126	7157	1	3081
1987	0	2.307545	40	152	4381	1	3162
1988	0	2.617918	46	128	3095	1	3174
1989	0	2.55463	60	98	1593	1	3139
1990	0	3.706502	61	93	2542	1	9315
1991	0	3.477231	60	87	2750	1	9789
1992	0	2.200292	56	78	2872	1	9559
1993	0	2.182277	56	78	2570	1	10700
1994	1	2.014211	40	82	2872	1	9815
1995	0	2.15	60	73	2989	0	10450

1996	0	2.024645	55	99	3118	0	11249
1997	0	1.456664	55	119	3653	0	11688
1998	0	1.631865	55	119	3284	0	12621
1999	0	1.515261	55	119	3876	0	12998
2000	0	1.318063	55	79	69700	0	243040
2001	0	1.323724	30	145	86500	0	279677
2002	0	1.672727	50	87	103718	0	277613
2003	0	1.771669	50	87	106144	0	291493
2004	0	1.46213	37	118	203132	0	294641
2005	1	1.253921	30	145	213995	0	300833
2006	0	1.427446	33	303	246791	0	313888
2007	0	1.305669	36	230	284712	0	351144
2008	0	0.997955	43	233	257860	0	520137
2009	0	1.080751	40	125	807812	0	642431
2010	0	2.788428	42	254	2801664	0	602234
2011	0	2.600104	44	158	2187015	0	728759
2012	0	1.177856	39	179	2936510	0	900899
2013	0	1.340483	26	151	2912784	0	1113597
2014	0	1.265632	21	187	2821569	0	1398227
2015	0	1.46316	24	191	3103751	0	1590646
2016	1	1.414713	29	180	3624729	0	1851437
2017	1		29	180		0	

Appendix 2: Regression results

Long-run regression models; Output Model

Source	SS	df	MS			
				Number of obs	=	50
				F(6, 43)	=	6.66
Model	2.5740981	6	.42901635	Prob > F	=	0.0000
Residual	2.76985839	43	.064415311	R-squared	=	0.4817
				Adj R-squared	=	0.4094
Total	5.34395649	49	.109060336	Root MSE	=	.2538

lnoutput	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnrelativeprices	-.0131629	.1734166	-0.08	0.940	-.3628909	.3365651
lnhectarage	.3684569	.098222	3.75	0.001	.1703734	.5665404
rainfalldummy	-.1114076	.1052001	-1.06	0.296	-.3235639	.1007487
dummysaps	-.1275174	.0976281	-1.31	0.198	-.3244033	.0693685
logresearchexpenditure	-.2119534	.0734533	-2.89	0.006	-.3600861	-.0638208
lnpriceinputs	.2004294	.0546452	3.67	0.001	.0902268	.3106319
_cons	.5670319	.5799485	0.98	0.334	-.6025456	1.736609

Long-run regression models; Hectarage Model

Source	SS	df	MS			
				Number of obs	=	50
				F(6, 43)	=	20.05
Model	7.48466916	6	1.24744486	Prob > F	=	0.0000
Residual	2.67508841	43	.062211358	R-squared	=	0.7367
				Adj R-squared	=	0.7000
Total	10.1597576	49	.207341991	Root MSE	=	.24942

lnhectarage	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnrelativeprices	.2124046	.1530585	1.39	0.172	-.0962673	.5210764
lnhectarage						
L1.	.8181069	.1203484	6.80	0.000	.5754012	1.060813
lnyield						
L1.	.1203959	.1290484	0.93	0.356	-.139855	.3806467
dummysaps	-.0839791	.0946552	-0.89	0.380	-.2748695	.1069114
logresearchexpenditure	-.0081152	.0254047	-0.32	0.751	-.0593487	.0431184
rainfalldummy	-.1253801	.1070865	-1.17	0.248	-.3413405	.0905804
_cons	.0775959	1.015979	0.08	0.939	-1.97132	2.126512

Short-run error correction models; Output Model

Source	SS	df	MS
Model	2.06072003	7	.294388576
Residual	2.4670963	41	.060173081
Total	4.52781634	48	.094329507

Number of obs	=	49
F(7, 41)	=	4.89
Prob > F	=	0.0004
R-squared	=	0.4551
Adj R-squared	=	0.3621
Root MSE	=	.2453

D.lnoutput	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnrelativeprices						
D1.	.1843633	.1638318	1.13	0.267	-.1465016	.5152282
lnhectarage						
D1.	.3942694	.1485262	2.65	0.011	.0943146	.6942242
rainfalldummy	.0072619	.1125349	0.06	0.949	-.2200069	.2345308
dummysaps	-.0395294	.095316	-0.41	0.681	-.2320239	.1529652
logresearchexpenditure						
D1.	-.3037523	.1141551	-2.66	0.011	-.5342933	-.0732114
lnpriceinputs						
D1.	.2427566	.0942142	2.58	0.014	.0524872	.4330259
residual						
L1.	-.5950199	.1567996	-3.79	0.000	-.9116832	-.2783567
_cons	.0207854	.0448366	0.46	0.645	-.069764	.1113349

Short-run error correction models; Hectarage Model

Source	SS	df	MS
Model	.700054494	7	.100007785
Residual	2.758924	41	.067290829
Total	3.45897849	48	.072062052

Number of obs	=	49
F(7, 41)	=	1.49
Prob > F	=	0.1992
R-squared	=	0.2024
Adj R-squared	=	0.0662
Root MSE	=	.2594

D.lnhectarage	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnrelativeprices						
D1.	.165206	.1653835	1.00	0.324	-.1687928	.4992048
lnhectarage						
LD.	.7224836	.3270669	2.21	0.033	.0619585	1.383009
lnyield						
LD.	.1522586	.1268464	1.20	0.237	-.103913	.4084301
dummysaps	-.0209632	.0978799	-0.21	0.831	-.2186357	.1767093
logresearchexpenditure						
D1.	.0579691	.0848342	0.68	0.498	-.113357	.2292953
rainfalldummy	-.1242885	.1173696	-1.06	0.296	-.3613211	.1127442
residual_model2						
L1.	-.836314	.3484727	-2.40	0.021	-1.540069	-.1325591
_cons	.0029248	.0462012	0.06	0.950	-.0903805	.09623