SUPPLY RESPONSE ANALYSIS OF THE SUGARCANE OUTGROWERS IN TANZANIA

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ABSTRACT

There are many arguments that increasing food self-sufficiency in sub-Saharan Africa (SSA) could reduce the high food price escalations which are often related to the increasing demand and importation of food commodities. In Tanzania, sugar is one of the agricultural commodities being imported to meet the country's high sugar demand for domestic and industrial use. Currently, the overall annual sugar demand in Tanzania is about 600 000 metric tons against the country's annual sugar production of about 350 000 metric tons. The study attempts to examine the supply response of the sugarcane out-growers to price and non-price factors using the Error Correction Model (VECM) l to analyse time series data covering the period 1996 to 2018. The findings indicate that the short-run own price elasticity for sugarcane was 0.954 while the long-run elasticity was 4.525343, cross price elasticity was -0.654929 in the short-run while the long-run elasticity was -3.8184. For non-price factors area harvested, amount of cane produced were significant in the short-run with estimated elasticities of -0.41956 and 0.5063 respectively. In the long run all non-price factors were significant with estimated elasticities of 0.1915, 3.4759 and 0.0137 for sugarcane production, rainfall and trend factors, respectively. These results imply that, sugarcane producers are more responsive to price factors than non-price factors. The fact that all the variables were significant in the long-run implies that farmers need time to adjust their production in response to changes in the mentioned factors. The very small estimate for the trend factor implies that there has been a very small adoption of productivity enhancing technologies during the 1996-2018 period. To achieve her self-sufficient endeavour, the Tanzania Government should invest in rural infrastructure and appropriate technological improvements as long-term strategies to improve sugarcane supply, encourage policies geared towards making sugarcane a more attractive enterprise and design strategies to improve the use of yield-enhancing inputs like fertilizers.

DECLARATION

I, **Ismail Ally Mbua**, do hereby declare to the senate of Sokoine University of Agriculture, that this dissertation is my original work done within the period of registration and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

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DEDICATIONS

This work is dedicated to sugarcane out-growers, sugar manufacturers, Sugar Board of Tanzania and all other stakeholders in the sugar industry.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
ARDL	Autoregressive Distributed Lag Models
AVC	Average Variable Cost
BLUE	Best linear unbiased estimators
Chi-sq	Chi-square
CSA	Central Statistical Authority
DF	Dickey-Fuller
df	Degrees of freedom
DFGLS	Dickey-Fuller GLS-detrended
DNA	Deoxyribonucleic Acid
DSD	Directorate of Sugarcane Development
ECM	Error Correction Model
ECT	Error Correction Term
ERS	Elliot-Rothenberg-Stock
FAO	Food and Agricultural Organization of the United Nations
FPE	Final Prediction Error
GDP	Gross Domestic Product
HQ	Hannan Quinn Information Criterion
ISO	International Sugar Organization
LM	Langrange Multiplier Test
LR	Likelihood Ratio
MAFAP	Monitoring and Analysing Food and Agricultural Policies
ML	Maximum Likelihood
NP	Point Optimal and Ng-Perron

OLS	Ordinary Least Square Method
PP	Phillips-Perron
prob	Probability
SBT	Sugar Board of Tanzania
SC	Scharz information criterion
SSA	Sub Saharan Africa
TPC	Tanganyika Planting Company
URT	United Republic of Tanzania
VAR	Vector autoregressive
VECM	Vector Error Correction Model

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Sugar is one of the most important commodities to most people in most parts of the world. Sugar is used as an important complement to other foods such as tea, coffee and milk. Also, sugar is used as an important component in many manufactured food products such as beer, yoghurt, and bread (Zhao, 2015). Sugar mainly comes from two sources namely sugar-cane and sugar beet. Approximately 80% of the sugar in the world is produced from sugarcane in tropical and subtropical climates, while the remaining 20% derived from sugar beet, and is mostly produced in the temperate zones of the northern hemisphere (Walton, 2020). Currently, about 110 countries produce sugar from sugarcane and eight countries produce sugar from both cane and beet (ISO, 2020). Besides sugar production, sugarcane can be used to produce valuable products such as ethanol which is used as a fuel, bagasse used for papers, chipboard and press mud used as a rich source of organic matter and nutrients for crop production (Saddiq *et al*., 2014).

The top ten sugar producing countries in the world are India, Brazil, Thailand, China, US, Mexico, Russia, Pakistan, France and Australia which account for nearly 70% of global sugar output (Martiniello and Azambuja, 2019). Sub-Sahara Africa (SSA) contributes only about 5% of the global sugar production. Sugarcane is grown in most countries in SSA but five countries account for more than half production of the continent. These are South Africa, Sudan, Kenya, Swaziland and Mauritius (Hess *et al*., 2016). The SSA countries have the highest production potential due to relatively low costs of production, primarily due to ideal growing conditions such as undulating topography, clay soils, availability of water that could provide supplementary irrigation, and ambient weather conditions especially temperature and solar radiation which support high growth rates and conversion to sucrose (Hess *et al*., 2016).

In Tanzania, sugarcane production is undertaken by sugarcane estates or plantations and out-growers who are small scale farmers linked to large scale sugarcane estates or plantations owned by sugar manufacturing companies (Bakari, 2018). Sugarcane in Tanzania is mainly used for sugar production. Currently, there are five active sugar companies in the country that produce sugar commercially namely Kilombero Sugar Company (KSCL) and Mtibwa Sugar estates in the Morogoro Region, Tanganyika Planting Company (TPC) in Kilimanjaro Region, Kagera Sugar Company in Kagera Region and Manyara Sugar Company in Manyara Region. As per the Tanzania Sugar Industry Act of 2001, the sugar industry is regulated by the Sugar Board of Tanzania (SBT) under the Ministry of Agriculture (Sulle, 2017).

Sugarcane production is an important subsector in Tanzania’s economy. It contributes approximately 35% of the gross output of the food-manufacturing sector and some 7 to 10% of total manufacturing value added (Massawe and Kahamba, 2018). Being among the largest agro-processing industries in the country, the sugar subsector is a major employer with direct labour force of approximately 18,000 people, indirect labour force of 57 000 people with 75 000 households and dependents (Massawe and Kahamba, 2018).

Despite the enormous potential for sugarcane production, Tanzania is a net importer of sugar (Mwinuka, 2015). The country has persistently been importing sugar yearly to cover the deficit. This reflects a high demand of sugar in the country. The major drivers of sugar demand are reported to be population growth and per capita income (ISO, 2020). The high demand of sugar has led to the frequent rise in retail price of sugar in the country, making sugar to become a luxury good as low income families cannot afford it (Sulle *et al*., 2014).

The government has intervened in several ways in order to bridge the gap between sugar supply and demand. In 1998, the government introduced the privatization policy in the sugar subsector (Amrouk *et al*., 2013). In 2018/2019 budget the government proposed increase in sugar import duty from 25% to 35 % so to protect the sugar industries (Masare, 2018). The government, from time to time, has also set indicative sugar price in order to encourage the millers to increase production, and attracting new investors in the sector (Abdu, 2016). Furthermore, the Sugar Board of Tanzania plans to increase sugar production from 320 000 tons annually to 420 000 tons annually by 2020-2022 (Masare, 2018). In order to achieve the 100 000 tons of sugar annual increment in production that will ensure self-sufficiency in sugar in the long run, it is necessary to provide incentives not only to companies to invest in sugar processing factories but also to producers of sugarcane because sugar factories in Tanzania depend greatly on sugarcane supply from the out-growers. Therefore, promoting sugarcane production among the out-growers would be the most significant first step to increase sugar supply to meet the country's sugar demand.

The out-growers comprise of numerous individual farmers mostly small-scale farmers with varying land sizes less than 20 acres (Sulle, 2015). They are the most vulnerable, and face lots of challenges such as harvest delay, payment delay, small cane pricing, poor infrastructure, low capital and depend on rainfall to mention few (Sulle, 2017). Therefore, the Out-growers are struggling with payment delays or payments that are lower than expected. Some are making financial losses from sugarcane production. Consequently, most of them respond by taking out loans, raising money using alternative ways or cutting back on expenses on sugarcane production to cover the shortfall (Sulle, 2015).

1.2 Problem Statement and Justification

As indicated in section 1.1, the government has intervened in several ways in order to bridge the gap between domestic sugar supply and demand. These interventions include the privatization policy in the sugar subsector in 1998 (Amrouk *et al*., 2013), increase in sugar import duty from 25 to 35 percent in 2018/2019 budget to protect the sugar industry (Masare, 2018), setting indicative price for sugar from time to time, encouraging millers to increase production, and attracting new investors in the sugar sector (Abdu, 2016).

These interventions and the persistent rise in retail sugar price are expected to be incentives for sugarcane growers to increase production. However, this has not been the case. This leaves behind questions regarding the out-growers response to sugar price and the government interventions worth of research attention. The key question is ‘If the out-growers are not increasing sugarcane production in the face of rising sugar price and the government interventions, are there important factors that influence sugarcane production other than the sugar price and the government incentives?’. The dissertation at hand is an attempt to answer this question and inform the government on effective policy interventions that can promote sugarcane production in the country. Muchapondwa (2009) argues that the application of agricultural policy instruments on agricultural activity without an empirical understanding of the structural parameters of supply may lead to unintended results. It is in this context that a thorough analysis of the factors influencing sugarcane supply by the out-growers to the sugar processing companies is needed in order to inform the government on appropriate interventions to use to promote out-growers' sugarcane production.

Admittedly, there is a dearth of literature on factors that influence sugarcane supply in Tanzania. Although studies on sugarcane supply response have been done elsewhere (see for example Mutua (2015) in Kenya, Muchetu and Mazwi (2015) in Zimbabwe and Suleiman (2001) in Ethiopia), country specific studies are necessary for informing policy due to differences in socio-economic circumstances across countries. Unfortunately previous empirical studies on sugarcane out-growers carried out in the Tanzania were on aspects other than supply response. For example the studies by (i) Msuya and Ashimogo (2005) on estimation of the technical efficiency of Mtibwa sugar estate out-growers scheme compared the efficiency level between out-growers and non-out-growers, (ii) Bombo (2013) on transaction costs in sugarcane production examined transaction costs among out-growers schemes in Morogoro region, (iii) Bakari (2018) on sugarcane supply to Mtibwa factory estimated the farm level technical efficiency, measuring profitability of out-growers and lastly determined constraints the out-growers face. All these studies have addressed issues in out-growers sugarcane production in Tanzania in one way or another. However, none of these studies have addressed the issue of the level of adjustments required by sugarcane out-growers to meet the needed sugarcane quantity and hence attain the intended sugar self-sufficiency in the country. Again what speed of adjustment is needed to establish a long-run equilibrium for attaining sustainable sugarcane supply to the millers?

Therefore, this study attempts to examine the Tanzanian sugarcane out-growers' response to price and non-price factors. It aims at determining the level and speed of adjustments for sugarcane out-growers to meet planned sugarcane supply to millers in Tanzania as step towards attaining sugar self-sufficiency in the country in the long-run. This study will provide complementary information to the previous studies so as to provide information for policy formulation for the sugar sub-sector in Tanzania.

1.3 Objectives

1.3.1 Overall objective

To examine sugarcane production trend and effects of price and non-price factors on sugarcane supply among sugarcane out-growers in Tanzania.

1.3.2 Specific objectives

(i) To analyse the trend in Tanzanian outgrowers' sugarcane production and prices of sugarcane for the 1996 -2018 period.

(ii) To determine effect of price and non-price factors on sugarcane supply by out-growers in Tanzania.

1.3.3 Research questions

The study is guided by the following research questions:

(i) What were the government interventions to promote sugarcane production during the past 35 years?

(ii) Had sugarcane production among outgrowers increased as a result of rising sugar prices and the government interventions?

(iii) If sugarcane production among outgrowers has not increased, were there important factors that influenced sugarcane production other than the sugar price and the government incentives?

1.3.4 Hypotheses

(i) Sugar production and price of sugarcane do not move in the same direction

(ii) Price and non-price factors do not have significant effect on the out-growers sugarcane supply response in Tanzania.

1.4 Scope and Limitation of the Study

The dissertation sought to examine sugarcane production trend and effects of price and non-price factors on sugarcane supply among sugarcane out-growers in Tanzania. The analysis covered a period of 22 years from 1996 to 2018. The length of the period was short due to problems of data availability. Short time period had a serious consequence in the analysis as it limited the number of variables that could have been included in the VECM. Important variables like sugar imports and exports were not included in the model due to the problem of degrees of freedom (Asteriou and Hall, 2007). Privatization policy variable was not included in the model because most of the data available were during the post policy period. The different types of data were obtained from different sources due to problems of getting a single source with dataset containing all the variables of interest. The trend analysis involved land area planted with sugarcane, sugarcane output and sugarcane yield.

1.5 Organization of the Dissertation

This dissertation is organized in five chapters as follow; Chapter One draws premises of the dissertation by providing contextual background and problem statement. It also presents objectives and hypotheses of the study. Next to Chapter One is Chapter Two that presents theoretical and empirical review of previous related studies on supply response. Chapter Three is on methodology and it describes data set used and analytical framework.

The findings of this study are presented and discussed in Chapter Four. The Chapter presents results of the analysis of trend in area planted with sugarcane, sugarcane production and yield among out-growers in Tanzania for the period 1996 to 2018, followed by the results of the estimation of the supply response function. The last chapter of the dissertation is Chapter Five that draws conclusions and provides recommendations based on the major findings of the study.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Theoretical Background

This study was guided by the theory of the firm. A firm is an association of individuals who have organized themselves for the purpose of turning inputs into outputs (Gravelle and Rees, 2004). For this case sugarcane out-growers are firms. Therefore, sugarcane out-growers like many other Firms pursue the goal of achieving the largest economic profit possible from sugarcane production (Nicholson and Snyder, 2008). And this could be easily illustrated through the following mathematical equation

$\pi(q) = P(q).Q - C(q) = R(q) - C(q)$ ……………………………………………………(1)

Where

$\pi(q)$ is profit the sugarcane out-growers pursue

P(q). is the per unit price in Tanzanian shilling of the sugarcane produced by out-growers

Q is the quantity of sugarcane supplied by out-growers to the sugar manufacturers

C(q) is the total cost incurred in Tanzanian shilling by the sugarcane out-growers during the whole production process

R(q) is the total revenue received in Tanzanian shilling by the out-growers from the sugar manufacturers

Each sugarcane out-growers have to decide on the amount of the sugarcane they will have to supply to deliver to sugar manufacturers or the area he or she is ready to invest to sugarcane production given the resources at his or her disposal so as to obtain the maximum profit from his or her investment.

Therefore the amount of sugarcane delivered to the sugar manufacturers would be the ones that any additional input would not add profit to the sugarcane out-growers. This could be achieved by the first order condition which leads to marginal costs to be equal to the marginal revenue, and any additional input would lead to decrease in the marginal revenue which can be confirmed when the second order derivative is less than 0.

Mathematically the first order and second order conditions for the firm could be obtained as follows.

From $\pi(q) = P(q).Q - C(q)$……………………………………………………….…..(2)

Where the symbols are as previously defined,

The first order conditions (FOC) are

FOC $\pi'(q) = P - MC(q) = 0$……………………………………………………..……(3)

Where

$\pi'(q)$ is the marginal revenue or is the revenue received by sugarcane out-growers from the last tone of sugarcane they delivered to the sugar manufacturers.

P is the price of the sugarcane per tonne received by out-growers from sugar manufacturers

MC(q) is the marginal cost or the cost the sugarcane out-growers incur for producing one more tone of sugarcane. Therefore the sugarcane out-growers will continue to use more inputs for this case area under cultivation, fertilizers, more water etc, as long as the MC does not exceed the marginal revenue.

The second order conditions (SOC) would be as follows

SOC $\pi''(q) = MC'(q) < 0$ ……………………………………………………..……(4)

Where

$\pi''(q)$ is the second order deliberative of sugarcane out-growers which is less than one. This means that the additional use of inputs will cause the decline in the revenue. Therefore the sugarcane out-growers will not add more input in the production process because any addition of input will cause a decline in the revenue.

At any given moment the sugarcane out-growers will supply amount of sugarcane when MC=MR=P. So the MC curve will represent the supply curve of the price taking individual firm. However, the entire range of MC function is not a firm's output supply function. The firm's output or product supply function is given by the disjoint function

$$q^* = \{ q^* (q, P_{x1}, P_{x2} P_{xn}) \text{for } P \geq \text{minimum AVC}$$

$$0 \text{ for } P < \text{minimum AVC} \ldots\ldots\ldots\ldots (5)$$

Where

q* is the quantity of sugarcane the sugarcane out-growers would supply to the sugarcane manufacturers.

P_{x1} is the price of the first input used for the sugarcane production

P_{x2} is the price of the second input used by the out-grower in the production process

P_{xn} is the price of the Nth input used by the farmer in the production process

P is the price of sugarcane the out-growers would receive when delivering his or her sugarcane to the sugar manufacturers

AVC is the Average Variable Cost of the inputs incurred by the sugarcane out-growers

So the supply function of the firm is Q along all the points in a MC curve where P is greater than or equal to average variable cost (AVC) and the supply is zero for the points below that (Gravelle and Rees, 2004). This imply that the sugarcane out-growers will only supply sugarcane to sugar manufacturers when they are able to meet their variable cost below that they will exit to go do other production activities.

However the sugarcane out-growers do not know these complicated mathematical calculations and mostly relay on what they can see. They will decide to either increase the area under cultivation or to decrease it given the profit received in the last seasons. The more the profit they got in the previous season the more they would allocate land for sugarcane production.

So the sugarcane out-growers decision to produce more or less (supply) will depend on the additional revenue expected for each unit input added during the process of production (Nicholson and Snyder, 2008).

The sugarcane out-growers supply response falls into two categories namely short-run and a long run. In short-run the firms can only change the amount of the input to increase the supply. The out-growers sugarcane market supply is equal to the quantity of output supplied to the entire market which is the quantity supplied by all sugarcane out-growers which depends on market price. If Qi(P,V,W) is the individual firm short-run supply then the market supply would be $Qs(P,V,W) = \sum_{i}^{n} Qi\ (P,V,W)$ (Nicholson and Snyder, 2008).

Where

Qi is amount of sugarcane supplied in a short-run by an individual out-grower

P is the prevailing market price of the sugarcane at the sugar manufacturers

V is the cost of first input used for sugarcane production

W is the cost of the second input used for sugarcane production

Qs is the total Market supply of sugarcane

$\sum_i^n$ is the summation of all the amount of sugarcane supplied to the sugar manufacturers by out-growers

In a long run, sugarcane out-growers can increase or decrease the amount of input in the production process for example use more or less fertilizers so to increase or decrease sugarcane production and hence to supply more or less to the sugar manufacturers. Also in the long run more people could go to sugarcane production when they see it is more profitable and vice versa. Therefore, there is more entry and exit in the sugarcane production. Lastly those already in the sugarcane production process might allocate more land for sugarcane production when they see it is more profitable and vice versa (Nicholson and Snyder, 2008).

2.2 Review of Analytical Approaches

2.2.1 Growth rate trend analysis

Trend estimation refers to the relationship between the variables of interest and time Fabian *et al.* (2013). Trend estimation technique uses linear regression techniques to obtain the coefficients of the variable and growth rate. This relationship between variable of interest and time can be in many ways including linear relationship, quadratic relationship, exponential trend, logistic trend or polynomial trend depending on the nature of the data.

Exponential trend has been used in many studies among the other trend estimation techniques. Some of these studies include Ramachandra (2006), who estimated the growth trend in area, production and productivity of sapota fruit in Karnaaka state in India. The author found that there was a positive growth rate of 4.5% per annum in area and negative growth rate in production and productivity of -1.98% and -6.24 respectively.

Similarly Gurikar (2007) also applied the exponential model to study the trend growth in area under cultivation and quantity of onions produced. The researcher was able to conclude that there was a positive significant growth rate in onion production and area. Khan *et al.* (2002), Fabian *et al*. (2013) used the exponential model to analyse the trend growth in area, production and yield for rice and cashew nuts respectively in Tanzania. The findings of Khan and Fabian showed both of the crops under investigation had a positive growth rate in production and yield.

Simple mathematical approach to exponential trend model

Exponential model is comes in a simple form as equation 6 below

$Y = a e^{bt}$ …………………………………………………………………….…….. (6)

Where

Y = area, production or yield

a = intercept

t = time

b = the growth rate

The exponential model is linearized without changing the meaning by introduction of the natural log to obtain equation below. The model is linearized for easy regression and interpretation of the model.

$\text{Ln } Y = \text{Ln } a + b t$……………………………………………………………….. (7)

2.2.2 Supply response

The magnitude and direction of the sugarcane out-growers supply response can be evaluated by estimating the elasticities of supply, in which there are two broadly approaches usually used, namely profit maximization approach and the use of the dynamic models approach.

2.2.2.1 Profit maximization approach (Direct approach)

The profit maximization approach to the supply estimation technique is also known as the direct structural approach. The approach involves the estimation of the supply response from Hotelling's lemma whereby there is a joint estimation of the output supply and input demand functions (Suleiman, 2001). The approach requires the detailed information of all inputs prices. Also the approach is mostly applied for the cross-sectional data. Suleiman (2001) examined the responsiveness of peasant farmers to changes in price and non-price factors in Ethiopia using the quadratic production function and restricted profit functions as summarized in the equation below.

$$\Pi^* = \alpha_0 + \sum_i^2 \alpha_i Wi^* + \sum_k^7 \beta_k Z_k + 0.5(\sum_i^2 \sum_j^2 \delta_{ij} W^*_i W^*_j + \sum_k^7 \sum_h^7 \lambda_{kh} Z_k Z_h) + \sum_i^2 \sum_h^2 \theta_{ih} W_i^* Z_h + D + \varepsilon \qquad (8)$$

Where

Π^* = normalized restricted profit

Wi^* = price of input i normalized by output price P which are 1= fertilizer price, 2= wage rate

Z_k = quantity of the fixed input or other exogenous variable k, in which K = 1 is area, 2 is animal power, 3 is farm capital, 4 is land quality, 5 is land access, 6 is road quality, 7 is rainfall.

The profit maximization approach follows the perfect competitive market (PCM) assumptions which in the real world farmers supply response may not be true. One of the reasons for this is that there is a biological lag between the application of the inputs and when the output of the cultivation process comes. Sometimes technological and institutional factors may prevent intended production decisions to be met in one production period (Mutua, 2015). Lastly, the assumptions of the perfect information cannot apply to agricultural production because the production process depends on the environmental factors which are characterized by information asymmetries (Mutua, 2015).

2.2.2.2 Dynamic models approach (Indirect approach)

The dynamic models also known as the indirect approach are the most used in the supply response estimation. These are distributed lag models, autoregressive models (Nerlovian model), autoregressive distributed lag models (ARDL), vector autoregressive models (VAR) and vector error correction model (VECM) (Asteriou and Hall, 2007). These dynamic models make use of the time series data. These models have been developed over the years and have been used in estimation farmers' agricultural response. However, the model that stood among the others econometrically was the Vector Error correction model (VECM).

i) Cointegration and Vector error correction model (VECM) approach

The Vector Error Correction Model (VECM) is a special case of the VAR for variables that are stationary in their differences and co-integrated (Obayelu, 2010). If the variables are I(1) and co-integrated, then the VAR model should be modified to allow for the co-integrating relationship.

ii) Mathematical approach to the VECM

Consider a system of non-stationary two variables, that is X and Y. they can be estimated correctly using VAR model as

$\Delta Y_t = \delta_0 + \delta_1 \Delta X_t + V_t$………………………………………………………………….. (9)

Where

ΔY_t is the change in the dependent variable, which is area, production or yield of sugarcane out-growers in our study

ΔX_t is the change in independent variables which is the price and non-price factors in our study

δ_0 is the constant of our model

δ_1 is the coefficient of the independent variable

V_t is the error term

The above model shows a short run relationship between X and Y that is the sugarcane out-growers response in a short-run. However if they are cointegrated, meaning there is some sort of the long run equilibrium, that is

$Y^E = \alpha + \beta X^E$………………………………………………………………..………… (10)

Where

Y^E is the response variable at equilibrium

X^E is the independent variable at equilibrium

β is the coefficient of the dependent variable at equilibrium

α is the constant of the model

The equilibrium value of Y^E is given by a linear relationship of X^E. We can include a long run relationship in the model. The idea here is that the observed Y_t might be different from the equilibrium value, as equation below

$Y_t = C + \delta_1 X_t + \delta_2 X_{t-1} + UY_{t-1} + V_t$ ………………………………………………… (11)

Where

Y_t is this year's sugarcane out-growers response

Y_{t-1} is the last year's sugarcane out-growers response

X_t is this year's shock can be price or non-price factors

X_{t-1} is the last year's shock either price or non-price factors

C is the constant of the model or Y intercept

δ_1 is the coefficient of this year shock

δ_2 is the coefficient of last year's shock

U is the coefficient of the last year response can be area, production or yield

V_t is the error term

The observed Y_t not only depends on X_t but also depends on X_{t-1} meaning that Y_t takes some time to react to the changes in X_t. That is this year's response is partly due to this year's shock and the magnitude of the last year's shock X_{t-1} We Also suppose that there is some sort of dependent on lagged value of Y_{t-1}, again this could represent the time it takes for Y to adjust. U represents the degree of inertia. That means the next season of the sugarcane out-growers response depends also on this year's response (Lardic and Mignon, 2008).

Estimation of this model has two problems. First it doesn't say anything about the dynamic of Xt on Yt that is there is no economic content in the model. Second if Xt and Yt are not stationary will lead to spurious regression.

In order to account for the two problems some sort of mechanism is developed to this model. The variables in the model are differenced individually while maintaining the same meaning of the model so as to make them stationary. The lagged values of both X and Y are differenced in both sides of the equation and then rearranged to obtain the model below (Asteriou and Hall, 2007).

$\Delta Y_t = C + \delta_1 \Delta Y_{t-1} + \delta_2 \Delta X_{t-1} - \lambda(Y_{t-1} - \alpha - \beta X_{t-1}) + V_t$ ……………………………(12)

Where

$\lambda = 1 - U$ and $\beta = (\delta 1 + \delta 2)/ (1-U)$

$Y_{t-1} - \alpha - \beta X_{t-1}$ is a part of the equation showing the long run response of the farmers.

Size of coefficient $-(1 - U)= \lambda$ is the indication of speed of adjustment towards equilibrium. Small values of $-(1 - U)= \lambda$, tending to -1, indicate that economic agents remove a large percentage of disequilibrium each period. Larger values, tending to 0, indicating that adjustment is slow. Extremely small values, between -1 and -2, indicate an overshooting of economic equilibrium. A value of zero (i.e. insignificant), is indicative of no adjustment which is not an error-correcting mechanism. Positive values would imply that Y_{t-1} diverges from the long-run equilibrium path. This would be inconsistent with the entire notion of economic equilibrium and short-run adjustment. Therefore the good vector error correction model should have a negative coefficient of adjustment and its magnitude should not exceed -1. This is because the sugarcane out-growers take time to respond to price factors and non-price factors and they cannot respond fully in one production season.

If $Y_{t-1} < \alpha + \beta X_{t-1}$ which says Y is below the equilibrium value, farmers would respond by increasing a bit of Y in one time period and vice versa, hence we correct the error in the last period to adjust further towards equilibrium value of Y. This sort of error correction mechanism is why we call this an error correction model (Asteriou and Hall, 2007).

The conventional vector error correction model is written compactly as equation 26

$$\Delta y_t = \beta_0 + \sum_{i=1}^{n} \beta_i \Delta y_{t-i} + \sum_{i=0}^{n} \delta_i X_{t-i} + \gamma Z_{t-1} + \mu_t$$

…………………………… (13)

Where

$Z_{t-1} = ECT_{t-1}$ is the error correction term obtained as a lagged OLS residual from the following long-run cointegration regression;

$Y_t = ß_0 + ß_1 X_t + \varepsilon_t$ and is defined as $ECT_{t-1} = Y_{t-1} - ß_0 - ß_1 X_{t-1}$

The error correction term (ECT) explains that previous periods deviation from long run equilibrium which is the error, influences short run movement in the dependent variable

γ = coefficient of ECT and the speed of adjustment. It measures the speed at which Y returns to equilibrium after changes in independent variables.

μ_t Is the error term.

The error correction model (ECM) is important and popular for many reasons. Firstly, it is a convenient model measuring the percentage the sugarcane out-growers' could respond to the shocks namely price and non-price factors in one time period which has a very good economic implication (Asteriou and Hall, 2007). Secondly, the cointegration error correction models are formulated in terms of first differences, which typically eliminate trends from the variables involved; they resolve the problem of spurious regressions (Asteriou and Hall, 2007). A third very important advantage of ECMs is the ease with which they can fit into the general-to-specific approach to econometric modelling, which is, in fact, a search for the most parsimonious ECM model that best fits the given data sets (Asteriou and Hall, 2007). Finally, the fourth and most important feature of the ECM comes from the fact that the disequilibrium error term is a stationary variable by definition of cointegration. Because of this, the ECM has important implications; the fact that the two variables are cointegrated implies that there is some adjustment process which prevents the errors in the long-run relationship becoming larger and larger (Asteriou and Hall, 2007).

2.2.2.3 Modelling supply response

Beginning in the late 1950s with Nerlove's seminal study of agricultural response, development economists became very interested in testing whether farmers adjusted their agricultural output based on prices or other economic indicators. Since then many studies were done to examine farmers response to price and non-price factors that may or may not influence farmers supply decision where supply response studies for individual commodities have been found to be more informative than aggregate studies (Mose, 2007; Mythil, 2008; Ozkan *et al.*, 2011).

Agricultural supply response can be categorized in three ways namely production (output) which is the total production for all the area under production, acreage (area) and yield (output in one hectare) response (Sadoulet and De janvry, 1995). Askari and Cummings, (1997) argued that of the three supply response variant, the only variable that is really under the farmers' control is the area under the crop, so should be used as a proxy for supply response.

This claim might somehow be right, but still, there are some decisions that are in farmers' control that affect the yield hence production that may seem in the control of the farmer such as investment, fertilizer application etc. Nerlove (1956) and Mythil (2008) argue in favour of the acreage response by saying that yield and output may also be affected by uncontrollable factors such as rainfall and other weather conditions. So the observed value for yield or production may be representing the fluctuations on these environmental factors. Therefore production (output) or yield may not truly represent a reality of the farmers decision (Mutual, 2015). This is especially the case for sugarcane out-growers. Sugarcane out-growers are characterized by low fertilizer application rate, limited mechanization and lack of irrigation infrastructures therefore their farms are rainfed. So the only thing that is usually under their control in making farming decisions is usually increase or decrease in land allocation. So for the estimation of the supply response the acreage is the most appropriate variable. However using any of these factor as a proxy would lead into same conclusions in most cases (Mythil, 2008).

2.2.2.4 Specification of the functional form for the supply response estimation

This study intends to use time series type of data. This type of data are usually characterized by trend, cycle, seasonal, irregular, episodic and residual. Trend means smooth, long-term/consistent upward or downward movement. Cycle means rise and fall over periods longer than a year, for example resulting from a business cycle. Seasonal means within-year pattern seen in weekly, monthly or quarterly data. Irregular means random component which can be subdivided into episodic (unpredictable but identifiable) and residual (unpredictable and unidentifiable) (Asteriou and Hall, 2007). So some sort of data transformation usually is done to make the data analysable.

There are various specifications of functional forms in literature that can be adopted for supply functions. Among these are the linear, semi-log and double log functional forms (Gujarati and porter, 1999). The log-log functional form is the mostly used. The natural logs linearize the exponential trends in the series which makes the graph look smoother (Asteriou and Hall, 2007). When the functional form is linearized by taking logarithms, elasticities are obtained directly from the model as parameter estimates for the respective variables (Ozkan *et al.*, 2011). Additionally, this does away with the need to refer to the units of measurement of the variables in the regression (Greene, 2010). When there are more than one explanatory variable in the model, a multivariate double log functional form is applied. In the double log functional form, each partial derivative measures the elasticity of respective explanatory variables on the dependent variable while holding the effects of other variables constant (Gujarati and porter, 1999). These elasticities imply that a percentage change in the independent variable would induce a change to the dependent variable of the magnitude equal to the observed elasticities ceteris puribus. Therefore the elasticities would show the responsiveness of the production model given an increase or decrease in a particular incentive.

2.2.2.5 Empirical review of supply response

Balie *et al.* (2016) did a study on the supply of the main staple food crops such as maize, sorghum, rice, wheat, barley, beans, cassava, yam, potatoes and millet in the selected sub Saharan African countries including Bukinafaso, Ethiopia, Ghana, Kenya, Malawi, Malawi, Mali, Mozambique, Nigeria, Uganda and Tanzania. In their study they used the dataset from FAO developed for monitoring and analysing food and agricultural policies (MAFAP) program which provides prices at the producer, wholesale and border levels for selected value chains. The study used the time series data for the periods of 2005-2013.

The study went further to analyse the impact of direct incentives arising from border protection and government intervention in domestic markets, macroeconomic policies such as the exchange rate policy and variations in border prices. In this work the researcher used the nerlovian adjustment model to estimate the supply response. From the analysis the researcher observed that farmers producing staple food crops react to real price signals even if with limited intensity, direct price incentives arising from border protection and government intervention in domestic markets and price shocks at the border are more important than macroeconomic policies in influencing farmers' decisions. However omitting marketing costs from the supply response function leads to underestimation of the price elasticity and using wholesale instead of farm gate prices as proxy for producer prices leads to overestimation of the price elasticity.

Suleiman (2001), did a microeconomic analysis for supply response of the Ethiopian farmers to price and non-price factors. In his study he used the cross-sectional data from 15 villages across the country in which 1500 households were sampled. Two variable inputs, fertilizer and labour and three fixed input, total area under crop adjusted for quality, animal power and farm capital, three structural and conditioning factors namely land access, infrastructure and rainfall. These variables were fitted in the quadratic functional form and a normalized restricted profit function was obtained. The results showed both price and non-price factors affected the supply response of the farmers. However the price factors had little effect while the non-price factors are far more important in affecting production and resource use. The researcher also used both the primal and dual approaches and both produced the same results.

Kumawat and Prasad (2012) analysed the Indian sugarcane supply response using a time series data for the period of 1990 to 2010. The study used the nerlovian partial adjustment model. The author estimated two supply response functions separately for area and yield as dependent variables while price arrears, price of sugarcane, price of sugarcane relative to wheat and the price of sugar as the market factors and rainfall and area under irrigation as the non-market factors. The study revealed that, the increase or decrease in area was mainly determined by the price factors while sugarcane yield was determined by rainfall.

Mwinuka (2015) examines the performance of Tanzanian sugar export and estimated sugar export supply function for the period 1977-2013 and annual growth rates for the quantities of sugar produced, consumed and imported. The multivariate regression model was used in which dependent variable was taken to be quantity of sugar exported in metric tonnes while the independent variables were sugar export price, domestic sugar production, consumer price index and the gross domestic product (GDP) and exchange rate. The author tested the Dataset for unit root by Dickey fuller test, then autocorrelation using white noise test. The langrange multiplier test (LM) test was used to be familiar with the number of lagged values of dependent variables, maximum likelihood approach was used to test for cointegration. The results of the estimation showed that annual growth rates for production and consumption was 3% and 7% respectively. Sugar export price was positive and significant while consumer price index had negative relationship. GDP and exchange rate were not statistically significant.

Saddiq *et al.* (2014) conducted research in whole Khyber Pakhtunkwa on acreage response of sugarcane to price and non-price factors. The empirical analysis of this study was limited to annual data of 42 years from 1970 to 2011. The data on rainfall was obtained from Pakistan meteorological department, data regarding sugarcane yield, area and prices were obtained from agricultural statistics of Pakistan. These data were fitted in the nerlovian adjustment model. Data was analysed using Shazam and Stata. For the purpose of stationary of time series augmented dickey fuller test (ADF) was used. Vector auto regression was used to capture the linear interdependence among multiple time series. All the variables in the VAR model were treated symmetrically. Each variable had an equation explaining its evaluation based on its own lags of all other variables in the model. To check likely serial autocorrelation in the auto regression model, Durbin h statistics were applied. The study found that sugarcane price had a positive and significant effect on area allocation to sugarcane. If the expected price increased the area allocation to sugarcane will also increase. Rainfall was found to be insignificant while improved technological innovation will boost the sugarcane production.

Alemu *et al.* (2003) quantified the responsiveness of producers of teff, maize and sorghum to incentives using the error correction model (ECM) using the time series data from 1966 to 1994 obtained from FAO and central statistical authority (CSA). In the study the author used area planted as dependent variable while own price, substitute crop price, rainfall, time trend and dummy variables to present the structural breaks. The research found that planned supply of teff, maize and sorghum was positively affected by own prices, negatively by prices of substitute crops and variously by structural breaks related to policy changes and occurrence of the natural calamities. The study found significant long-run price elasticities for all crop and insignificant short-run price elasticities for all crops but maize. The researcher concluded that farmers do respond to incentive changes.

Kumar and Sharma (2006) did a study on perennial crops supply response, the case of the Indian rubber, tea and coffee. In the study the researcher made a distinction between short-run and long-run supply functions. The short-run supply response was estimated by fitting a yield function in which the major determinants of yield were the prevailing price in the market, technology, age composition of trees and rainfall. The long-run supply response was estimated by fitting an acreage function in which the major determinants were expected long-run profitability, the expected long-run profitability from competing crops, risk factor involved and some other factors associated with plantation of the crop like land surface and weather. The short-run results showed that the price was significant for all the crops while rainfall was significant except for rubber. In the long-run all the three crops own expected price had positive effects on the planted area, whereas the expected price of competing crops led to a decline in the planted area.

Fabian *et al*. (2013) examined the acreage response of cashew nut and sesame to commodity price and non-price factors in southern Tanzania. He estimated growth in the area, yield and production, then estimated supply response for sesame and cashew in Nachingwea and Mtwara districts and later obtained the short-run and long-run elasticities for the period 1995-2010. For the growth rates, the analyses were conducted through the linearized exponential growth model to trace the trends for the area, yield and production. The researcher found positive growth rates in the area, yield and production. For the supply response estimation, the nerlovian partial adjustment model was used where acreage was the dependent variable while the price and non-price factors such as rainfall were used as independent factors. The short and long-run price elasticities for sesame were 0.264 and 0.515 respectively in Nachingwea and 0.478 and 1.65 respectively in Mtwara. These results imply that the farmers are more responsive to price changes in the long-run than in the short-run. For cashew, short and long-run price elasticity were 0.326 and 1.364 respectively for Nachingwea and 0.37 and 0.885 in Mtwara respectively. However, the study did not find much difference between short and long-run non-price elasticities.

Antony (2016) conducted a study to explore the nature in which rice producers respond to price and non-price factors in terms of area under production. In this study time series data covering the period of 1999-2008 obtained from the Ministry of Agriculture, Food and Cooperatives, Tanzania Meteorological Agency and National Bureau of Statistics were used. The data were treated using nerlovian adjustment model. The data set was tested for stationarity and non-stationary data were made stationary as the nerlovian model requires data to be stationary. The results of this study showed that own price, price of the substitute crop which was maize, rainfall and fertilizer are important factors affecting farmers decision to allocate land.

2.2.2.6 Decision of variables used in the supply response studies

i) Dependent variables

The decision to use which variable to use is as explained in section 2.3.2. and as seen in many empirical studies reviewed in section 2.3.2.4 above. There are basically three variables that are mostly used as dependent variables or response variables, namely acreage (area), production (total output) and yield or productivity (output per unit area). Acreage is the one variable which is in direct control of the farmer as explained in section 2.3.2.

iii) Independent variables

Independent variables that are commonly used in acreage response studies include price and non-price factors. Of these explanatory variables, commodity prices have frequently been used for reasons discussed below. According to Minde (1991) and Rweyemamu and Kimaro (2006), producer prices are among the most important and effective tool for influencing the agricultural output. These prices are crucial in determining profit or loss in the farm enterprise. When producer prices are calculated in relation to the costs incurred by farmers in the production process, they lead to profit and provide the incentive to producers to grow more (Gurikar, 2007). This has led to increased attention on the effect of short-run changes in prices on production behaviour. Gurikar further asserts that in order to bring about sustained and balanced economic growth, it is very important to understand the long-run effect of prices on production.

Different forms of price factors have been used to study farmers' supply responses. For instance, Nosheen *et al*. (2011) used prices of a commodity received in the recent past to study farmers' response to price and other factors for rice production in Pakistan. The results showed positive price elasticity of acreage. In Cameroon, Molua (2010) used relative prices in his study on price and non-price determinants of acreage response on rice. He concluded that the area under rice would increase by 1.35% for a ten percent increase in world price relative to rice producer price. Meanwhile, Mohammad (2009) used lagged market price to estimate the Nerlovian adjustment model in studying the acreage response of wheat and cotton to respective price changes. Their results revealed that short and long-run price elasticities of wheat production were 0.0139 and 0.0274, respectively. Lagged prices of a commodity are often used in the model because prices received by the farmers in the recent past shapes economic incentive for the commodity. This is supported by Nosheen and Iqbal (2008) and Nosheen *et al.* (2011) who argue that farmers' resources allocation decisions are mainly based on the crop prices they received in the recent past.

However, price differences explain only part of the variation in the response variable. Acreage response has also been considered a consequence of changes in several non-price factors, which influence production. For this reason, a favourable price policy alone may not influence farmers to increase agricultural output through increased acreage. For instance, it is known that yield is an important determinant for the profitability of crops in a given year. Yet the yield of any crop at its planting time is not known. Farmers, therefore, base their expectation of profitability of a given crop on the yield realized in the recent past. Hence lagged yield enters the model as an independent variable. The lagged area is also used as an independent variable to capture the effects of farmers‟ know-how and experience with the given crop (Nosheen and Iqbal, 2008; Molua, 2010 and Nosheen *et al.*, 2011).

Other non-price factors are known to influence agricultural production. According to Gurikar (2007), changes in climatic factors, as well as incidence of pests and diseases adversely, affect agricultural production in the short-run while technological advancements cause long-run supply changes. Rainfall has been used as an independent variable quite frequently in empirical studies to represent non-price factors (Gurikar, 2007; Mythil, 2008; Mohammad, 2009; Molua, 2010). Meanwhile, technology has been represented by trend variable (Gurikar, 2007) to reflect its tendency to change over time. Different analytical innovations have been developed to accommodate other non-price factors. Based on the experience of other researchers as discussed in this chapter the analytical model for this study is presented in chapter three.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Conceptual and Analytical Framework

3.1.1 Conceptual framework

The relationship between dependent variables such as Area or output or yield and independent variables namely price factors such as sugarcane, competitive crop price and input prices, and non-price factors such as rainfall or irrigation, water availability, policy in the country, technological level, extension services, and education level can be briefly summarized in the Figure 1. The decision of the farmer to either increase or reduce the supply of the sugarcane or to reduce the supply of the sugarcane depends on the price factors and non-price factors. From economic theory, the supply response is mainly explained by the own price of the sugarcane. The farmers are expected to continue growing the sugarcane as price increase, but if the price was less than the other crops the farmer is expected to grow more of the other crop than sugarcane as the farmers are rational economic agents who seek to maximize profit. However the rationality of the farmer will depend on the cost of inputs to be used for each venture he/she chooses as this will determine capital to be invested, profits to be expected and the risks involved. Despite the price incentives, farmers' yield will depend greatly on the non-price factors such as the amount of rainfall as the crop needs water for proper growth and hence high yield. Also availability of the extension services as the farmers requires new skills to enhance crop productivity. Lastly, the price and non-price factors will work best depending on government policies at the given time period such as privatization. The farmer's supply response decision can either be to increase or decrease the area under sugarcane cultivation or to cultivate the same area more intensively or less intensively by either using more or fewer inputs such as fertilizers.

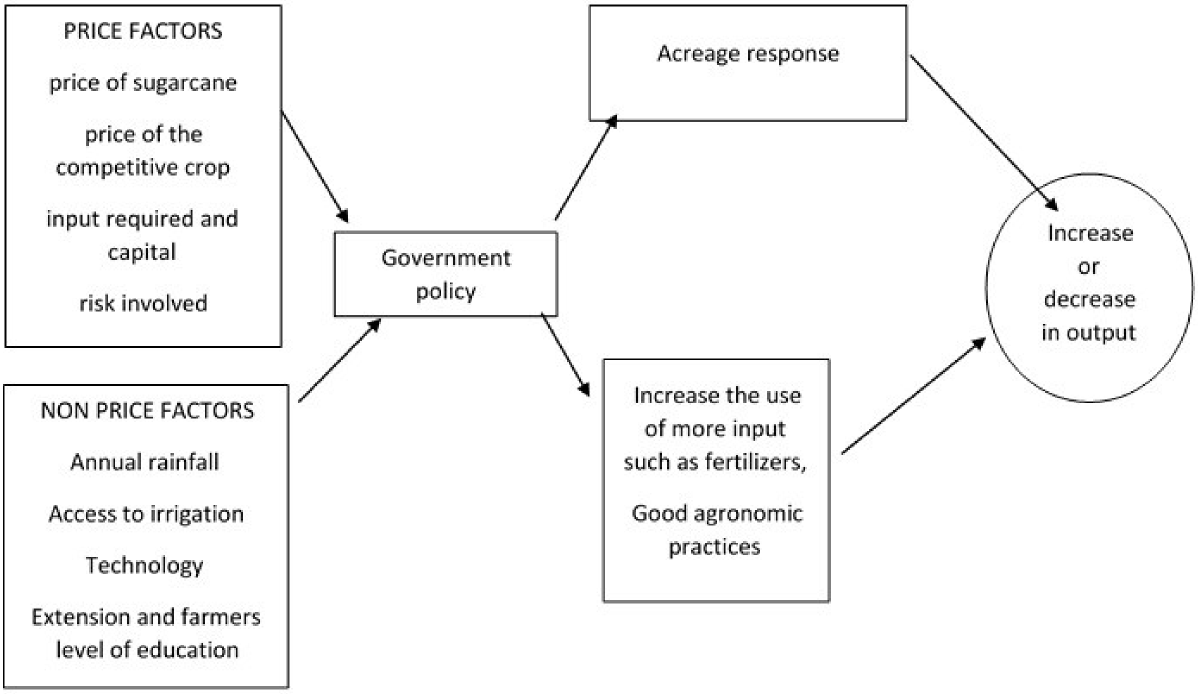

Figure 1: Conceptual framework for sugarcane out-growers' response to price and non-price factors

Source: Author's Construction

3.1.2 Analytical framework

3.1.2.1 Estimation of the yearly trend growth in area, production and yield for sugarcane out-growers from 1996 to 2018 production seasons

The following exponential model was used to analyse the trend in area, production and yield for sugarcane crop in Tanzania from 1996 to2018

$Y = a e^{bt}$ …………………………………………………..………………….. (14)

Where

Y = area, production or yield

a = intercept

t = time period in which 1996 was taken as period one and 2018 was taken as period 22

b = the average yearly trend growth rate in all 22 periods

The exponential model was linearized by transforming it into the natural log to obtain the following estimated model,

$$\text{Ln } Y = \text{Ln } a + b\, t \qquad (15)$$

3.1.2.2 Supply response estimation

The vector error correction model (VECM) was used to estimate the supply response of the sugarcane out-growers in Tanzania. The decision to use this model is backed by discussion in the literature review. The VECM is a special case of the Vector Autoregressive (VAR) models for variables that are stationary in their differences and co-integrated (Obayelu, 2010). The main reason for the choice of the model was that stationarity tests on the time series data collected for this study showed that all the series were non-stationary in their levels and co-integrated.

Price factors (sugarcane real price and rice real price) and non-price factors (sugarcane acreage, production, and annual rainfall) were used to estimate the sugarcane supply response. Rice real price was taken as a competitive crop because in most sugarcane producing regions there is also high rice production.

The farmers response to price and non-price factors is in most cases not by increasing more land into the production because they are constrained by the availability of land to expand more. Therefore farmers' response is through allocation of available land between the competing enterprises in the area. In our case the farmers' response is by allocation of the constrained land between sugarcane production and rice production.

3.1.2.3 Empirical model specification

The vector error correction model is specified in a log-log format and summarized as equation.

$$\Delta \ln A_t = \beta_0 + \sum_{i=1}^{k-1} \beta_{i1} \Delta \ln A_{t-i} + \sum_{i=1}^{k-1} \beta_{i2} \Delta lnSP_{t-i} + \sum_{i=1}^{k-1} \beta_{i3} \Delta \ln RP_{t-i} + \sum_{i=1}^{k-1} \beta_{i4} \Delta \ln R_{t-i} + \sum_{i=1}^{k-1} \beta_{i5} \Delta \ln Y_{t-i} + \gamma \{ l$$

$+ \quad \mu_t$ ……………………………………….……..…… (16)

Where;

Δ is the difference operator for the respective variable

A is the area harvested by the sugarcane out-growers each year in hectare

SP is the Sugarcane real price received by the sugarcane out-growers each year in Tanzania shillings per tonne. An increase in the price of sugarcane is expected to cause an increase in land allocation to sugarcane and less to rice production which leads to more supply of the sugarcane; it is expected to have a positive sign.

RP is the real price of rice as a competitive crop to sugarcane production in Tanzania shillings per tonne. An increase in the price of rice is expected to decrease land allocation to sugarcane and increase to rice production, therefore decreasing the supply of sugarcane. It is expected to have a negative sign.

R is the annual rainfall in millilitres. Water availability is an important factor for production of any plant. Sugarcane requires lots of water for better growth of the sugarcane plant. Most sugarcane out-growers farms are rainfed, therefore the higher the amount of rainfall available the more the expected supply of cane to the sugar manufacturers. Rainfall is expected to have a positive sign in our estimated model, Y is the amount of sugarcane produced every year in tonnes. This variable was put in the model to represent the effects of changes in non-acreage inputs and other exogenous variables that affect productivity like temperature changes, soil characteristics among others.

The profit expected from sugarcane cultivation by out-growers not only depends on the price but also the amount of sugarcane produced. If there was high amount of sugarcane produced by out-growers in a particular season farmers were expected to increase the land under the crop in subsequent seasons in anticipation for more profits resulting from better yields. Therefore the coefficient of sugarcane production variable at time t (Y_t) is expected to be positive in our estimated model.

TR is the time trend variable. It is used as a proxy for variables that could not be observed directly over the years which have huge impact on the dependent variable. Time trend represent variables like historical data on infrastructural development, applications of modern farming techniques and expenditure on agricultural research and extension services, among others (Alemu *et al*., 2003). These developments over time are expected to enhance yield and farming conditions to the farmers, therefore they will have positive impact on the supply response of the sugarcane.

Ln is natural log

μ_t is the stochastic error term. It is assumed to be independently and normally distributed with zero mean and constant variance.

βs are the short-run supply parameters. They measure the effect of a percent change in the respective explanatory variables on the dependent variable in the short-run.

k is the maximum number of lags included in the model as determined by the data properties.

γ is the error correction mechanism that measures the speed of adjustment from short-run disequilibria to long-run steady state equilibrium. It measures the extent of correction of errors in the dependent variable and its expected sign is always negative.

αs are the long-run coefficients for the independent variables.

Table 1: Summary of the description of the variables used in the model

Variable	**Variable name**	**Variable description**	**Unit of measure**	**Expected sign**
A_t	Area	Represent the natural log of the area planted with sugarcane by out-growers	Hectares	
A_{t-1}	Area	Is the previous period natural log of area planted with sugarcane by out-growers	Hectares	(-)
SP_{t-1}	Sugarcane price	Is the natural log of price of sugarcane deflated by the consumer price index	Tsh/tonne	(+)
RP_{t-1}	Rice price	Natural log of the price of rice deflated by the consumer price index	Tsh/tonne	(-)
R_{t-1}	Rainfall	Natural log of the annual rainfall received in previous year	Millilitres	(+)
Y_{t-1}	Sugarcane production	Natural log of amount of cane produced in previous year	Tonnes	(+)
TR	Time trend	Is the time trend variable showing change in technology	Years	(+)

3.1.2.4 Estimating the vector error correction model

The estimation of the model was done in steps as follows

Step 1; Performing a unit root test to test for stationarity.

There are various methods that could be used to measure the univariate properties of the time series. There are formal and informal methods. Informal methods use the observational procedures and graphs while formal methods use mathematical methods. Formal methods are Dickey-Fuller (DF), Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), Dickey-Fuller GLS-detrended (DFGLS), Elliot-Rothenberg-Stock (ERS)

Point Optimal and Ng-Perron (NP). Augmented dickey fuller test is the most used in many studies involving the time series (Alemu *et al*, 2003; Mutua, 2015; Antony, 2016), therefore this study also adopted this test.

Augmented dickey fuller test was used to test the Null hypothesis that the data series has a unit root against the alternative hypothesis that the series has no unit root. Failure to reject the null hypothesis (i.e. if the series has a unit root root) means that the data series is not stationary. Therefore the non-stationary data were tested for order of integration by differencing the data until it became stationary. The order of integration is equal to the number of times the data was differenced until it became stationary.

Step 2; Determination of optimal lag length for the model

The optimal number of lags for all the independent variables to be included in the vector error correction model was determined using the E-views 9 software. The VECM takes into account the maximum number of lags to be included in the model. The optimal number of lags has a serious economic implication as it determines the maximum number of periods from previous, the independent variables has effect on the supply response at a given time period. From E-views 9 several selection criteria were used to decide on the maximum number of lags namely modified LR test statistic (LR), final prediction error (FPE), Akaike information criterion (AIC), Scharz information criterion (SC) and Hannan Quinn information criterion (HQ). The respective criterion with the lowest number of lags is the ones selected (Asteriou and Hall, 2007).

Step 3; Conducting Johansen cointegration test

After verifying the variables are I(1) and selecting the lag length of the model then the Johansen cointegration test was conducted in order to find out if there is really a genuine long-run relationship between dependent variable and independent variables. The

Johansen cointegration tests the null hypothesis that there is no cointegration against alternative hypothesis that there is cointegration. The Johansen co-integration test is based on the maximum likelihood (ML) estimation and two statistics; trace statistics and maximum Eigen values (Jonahsen, 1988). If the rank of the matrix is zero, then there is no co-integrating relationship. However, if it is greater than zero, then there are a number of co-integrating relationships equal to the maximum rank. Cointegration is an over-riding requirement for any economic model using non-stationary time series data (Asteriou and Hall, 2007). The VECM specification takes into account the number of co-integrating relationships. The rank shows the number of long-run relationships that exist between the dependent variable and the explanatory variables. The rank of one means that there is only one linearly independent combination of the non-stationary variables will be stationary (Asari *et al*., 2011).

Step 4; Running the error correction model

After running the above three tests, our data series were non-stationary but integrated I (1) and time series are cointegrated. Therefore we ran the vector error correction model to examine both the short-run and long-run dynamics of the series.

3.1.2.5 Post-estimation tests

Vector error correction model uses ordinary least square (OLS) for estimation. OLS estimation technique has the assumptions and conditions that needs to be met so as to be able to make the best inference. The assumptions are like battery or backbone for the OLS estimation technique. Therefore Diagnostic tests are conducted on the error-correction model in order to determine whether any of the assumptions of the classical normal linear regression model are violated. These tests would ensure the validity of the model.

(i) Auto correlation test

Autocorrelation also known as serial correlation is the relationship between a given variable and a lagged version of itself over various time intervals. This occurs as a pattern and not a random process. Therefore residuals related to any observation are related to other observations hence correlation exists between residuals of differing time periods. The OLS method assumes that the disturbance term relating to any observation is not influenced by the disturbance term relating to any other observation. That is to say the OLS assumes no serial correlation.

The time series data usually suffer from high serial correlation that causes the residual variance to likely underestimate the true variance and R-square is likely to be overestimated. Even if not the case, variance of estimated parameters may be underestimated hence misleading inference using standard distributions. Therefore, the estimated VECM was tested for any serial correlation, by looking at Breusch-Godfrey LM test (Asteriou and Hall, 2007).

Breusch-Godfrey LM test Lagrange Multiplier test which tests hypotheses through augmented residual regression. It can be applied whether lagged dependent variables are included or not unlike Durbin-Watson test. The Breusch-Godfrey LM test tests null hypothesis that the VECM does not suffer from any serial correlation problems. For a well fitted VECM we expect to fail to reject the null hypothesis and conclude that the VECM residuals are not serially correlated.

(ii) Normality test

The OLS assume normality in the error term with zero mean. Any linear function of normally distributed variables is also normally distributed. Therefore, under the normality assumption of error term, the OLS estimators will also be normally distributed. Hence inference is possible using standard statistical distributions t-distribution, F–distribution and chi-square distribution. If the residuals are not normally distributed; consistency of estimators is not guaranteed and estimators do not conform to normal distribution hence inference not possible using standard distributions.

Jarque-Bera test was used to determine whether a variable is normally distributed. It measures the difference in kurtosis and skewedness of a variable compared to those from the normal distribution. Jarque-Bera tests the null hypothesis that the variables are normally distributed against the alternative hypothesis that the variables are not normally distributed. Therefore we are expected to fail to reject the null hypothesis to get a normally distributed VECM.

(iii) Heteroscedasticity

The OLS assume that the variance of the residual term is constant over differing values of the explanatory variables, the condition known as homoscedasticity. Violation of this assumption results in the condition known as heteroscedasticity. Therefore using OLS technique to estimate VECM under heteroscedastic would lead the residual variance to be a biased estimator of the true variance. Biased estimated variance of the parameter estimates may overestimate or underestimate and lastly misleading inference using standard distributions. The heteroscedasticity test was done using White's Heteroscedasticity test, which tests the null hypothesis that the VECM residuals are homoscedastic. We are expected to fail to reject the null hypothesis if we have estimated the best VECM.

(iv) Stability diagnostics test

A stability test was done to check the stability condition of the VECM estimates. The stability of a VECM refers to the ability of the system to revert back to the equilibrium after a shock. The estimated VECM was subjected to CUSUM test in E-views 9 statistical software. The CUSUM test produces a graph to show the ability of VECM to revert back to equilibrium. For the best VECM the blue line should not go beyond the red line boundaries.

3.2 Data Set and Data Transformation

The study used time series data from 1996 to 2018. The data were obtained from Tanzanian government institutions and international organizations as shown in Table 2.

Table 2: Source of data for the study

Type of data	Source
Sugarcane Area, Production and Yield	Sugar Board of Tanzania
Sugarcane Price	Sugar Companies
Rice Price	Ministry of Agriculture (URT, 2018)
Rainfall	World Bank (WorldBank, 2019)
Consumer price index	FAOSTAT (FAO, 2019)

The data on the sugarcane price were obtained from Mtibwa, Kilombero and Kagera sugar companies. These prices were used to estimate the average price paid per ton for the sugarcane by taking the sum of the price paid by the sugar companies then divide by the number of the companies to obtain an average price. In Tanzania there are two types of the sugarcane payment system namely the endearment payment system in which the sugarcane producers are paid depending on the sugar content of cane delivered which is the amount of sugar the company expect to extract from sugarcane delivered to the factory from the producer and then this amount calculated per hectare and weight payment system. So to avoid confusion between the two payment systems the sugarcane price was taken to be the price paid to one tone of sugarcane when the percentage sucrose content expected to be extracted is 10%. The sucrose content was taken to be 10% because it is the average for most of the sugarcane delivered to the factories from the out-growers.

The data were entered into the Microsoft excel for easy data manipulation and transformation to natural logarithm. From there the data were exported into E-views 9 statistical software so as to estimate the supply response model.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Trend in Sugarcane Land Area Planted with Sugarcane, Sugarcane Production and Yield Among Out-growers in Tanzania

In order to assess the performance of the sugarcane production in Tanzania a simple plot of the area cultivated, quantity of the sugarcane produced and production per unit area (yield) were plotted as shown in Figures 2) and then a simple trend analysis was done to get the growth rate in area, production and yield as seen in Table 3. As in Figure 2 there has been increase in the area planted with sugarcane from 3977 ha in 1996/1997 to 15907 ha in 2017/2018. Also the production of sugar cane increased from 347 035 tonnes in 1996/1997 to 568 083 tonnes in 2017/2018, while the yield of the sugarcane has been fluctuating from 90 to 60 tonnes per ha. The increase in area harvested each year has been mainly due to increase in the number of out-growers, while the production increase has been mainly due to increase in the area planted with sugarcane each year. However the yield has been decreasing as shown in Figure 2. This may be explained by the fact that the out-growers productivity is low due to poor infrastructure like irrigation and little or non-use of the fertilizers.

The trend estimation results as seen in Table 3 show that the area planted with sugarcane increased by 4.81% for the 1996-2018 period, while sugarcane production increase by 4.15%. The production growth rate is less compared with the acreage growth rate for the same period. Lastly, the growth rate analysis has shown an overall decline in the amount of sugarcane produced per hector at the rate of 0.66% for the 1996-2018 period. This can be explained by a number of factors such as continuous use of the same land, climatic factors and lack of capital. Use of the same farms every year coupled with little or no use of productivity enhancing inputs such as fertilizers may lead to decline in land productivity. Climatic factors can cause the decrease in the land productivity because all the out-growers in Tanzania depend on rainfall to produce sugarcane, so changes in the rainfall could also cause decrease in sugarcane yield per hectare. Financial factors could contribute to the decrease in the yield of the sugarcane production in the country as most of the Out-growers do not use the fertilizers or use less than the recommended amount for the sugarcane production because they are unable to afford it.

The growth rate results are slightly different to those obtained by Bader (2017) who estimated area, production and yield growth rates for sugarcane in Egypt. He got 0.32% growth rate in area which is smaller than our estimates, while production was found to decline at 0.64% which is opposite to our estimates which show an increase in sugarcane production at a rate of 4.15%. Sugarcane yield was found to be decreasing at 0.62% which is slightly lower than our estimates of 0.66%.

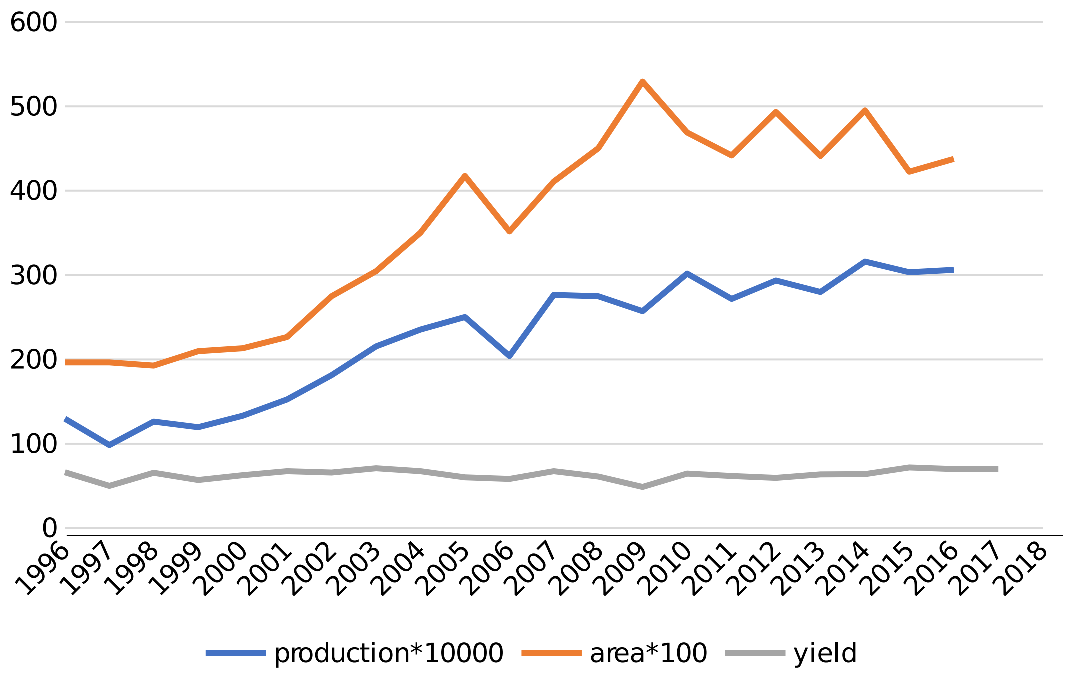

Figure 2: Trend of amount of sugarcane, area planted with sugarcane and yield produced by the out-growers in Tanzania from 1996 to 2018 period

Table 3: Summary of the results of growth rate analysis

Variables	**b0**	**B1**	**R squared**	**P value (B1)**	**Growth rate**
Area harvested	9.077431	0.048053	0.442972	0.000992	4.81%
Production	12.69153	0.041498	0.362983	0.003848	4.15%
Yield	3.614097	-0.00656	0.043179	0.366074	-0.66%

4.2 Results of Estimation of the Supply Response Function

4.2.1 Stationarity test

The data series on area harvested, annual rainfall, rice real price, sugarcane real price and amount of sugarcane produced were tested for unit root test for the period 1996-2017 and the results were as shown in the Table 4 at the level and at first difference respectively. The decision rule is to reject the null hypothesis when the absolute value of the test statistic is greater than the absolute critical value at 1%, 5% or 10% significant levels or the calculated P-value is less than 0.01, 0.05 or 0.1.

As seen in Table 4, the ADF test results at the level shows that the absolute ADF test statistic values for all the variables: rice price, sugarcane price, area planted with sugarcane, production and annual rainfall were all less than critical values at 1%, 5% and 10% significant levels, and the P-values were much higher than 0.01, 0.05 and 0.10 significant levels. Therefore we failed to reject the null hypothesis H0; The data series has a unit root, and conclude that the all the variable data series were non stationary at 1%, 5% and 10% significant levels.

After the ADF test at the level, the ADF test was then done to test the data series at their first difference and the results were summarized as seen in Table 4. The absolute ADF test statistic results on the differenced data series were greater than the absolute critical values at 1%, 5% and 10% significant levels and the P-values were less than 0.01, 0.05 and 0.10 significant levels, therefore we were able to reject the null hypothesis H0; that is the data series has a unit root and conclude that the data series for all variables were stationary at first difference.

Table 4: Results of the ADF test at the level and first difference

Variables	**At the level**		**First difference**		
	Test statistic	**P value**	**Test statistic**	**P value**	**Order of Integration**
Sugarcane price	-0.904321	0.93651	-4.326128	0.014	I (1)
rice price	-2.640547	0.2679	-5.346345	0.0019	I (1)
Out-growers production	-1.145926	0.8929	-4.762728	0.0001	I (1)
Area planted with sugarcane	-0.781864	0.9485	-5.385596	0.002	I (1)
Rainfall	-1.595747	0.7580	-7.468102	0.0000	I (1)

4.2.2 Lag length selection

The optimal numbers of lags were determined using Eviews 9 software and the results are as seen in Table 5. As seen in Table 5, the LR, FPE, AIC, SC and HQ lag selection criteria both selected the optimal lag for the data series rice real price, sugarcane real price area planted with sugarcane, sugarcane production, and rainfall to be one. So the optimal number of lags used for the estimation of the supply response function was one.

Table 5: Results for lag length selection criterion for out-growers as captured in Eviews 9

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	40.40707	NA	2.00e-08	-3.540707	-3.540707	-3.492113
1	96.38102	78.36353*	9.9e-10*	-6.638102*	-5.144504*	-6.346536*

* indicates lag order selected by the criterion

4.2.3 Cointegration test

The Johansen cointegration test was used to test the long-run relationship between the dependent variable and independent variables and the results are as shown in Table 6. From Table 6, it can be seen that the trace statistics value and Eigen values are both higher than the 0.05 critical values when the hypothesized number of cointegrating equations is none and at most 1. Also the probability values were less than 0.05 for the same hypothesized number of cointegrating equations. The results suggest that there is at most one cointegrating equation. Therefore we were able to reject the null hypothesis and conclude that there is indeed a long run relationship among the variables.

Table 6: Johansen cointegration test results based on unrestricted cointegration Rank Test (Trace) for out-growers

Hypothesized no of CE	Eigenvalue	Trace statistics	0.05critical value	Prob.**
None *	0.970392	141.0252	88.80380	0.0000
At most 1 *	0.866742	74.15066	63.87610	0.0054
At most 2	0.659314	35.85670	42.91525	0.2115
At most 3	0.419970	15.39761	25.87211	0.5416
At most 4	0.233350	5.048774	12.51798	0.5894

4.2.4 The vector error correction model estimation

Vector error correction model was developed after the confirmation that there was a long-run relationship between dependent variable (area) with the explanatory variables and the results are summarized in Table 7 as captured by E-views 9 software. In the short-run, the lagged difference (change) area under planted with sugarcane, the lagged difference of sugarcane production, the lagged difference of real sugarcane price and the lagged difference (change) real rice price were found to be significant. The first difference of the lagged area variable was found to be negatively (that is -0.419561) affecting the acreage response of the sugarcane out-growers. The P-values calculated by the software was found to be 0.0372 which was less than the 0.05 and 0.01 critical values. This led us to rejection of the null hypothesis and concludes that the first difference of the lagged area planted with sugarcane does affect the acreage supply response of the sugarcane producers.

The own price of the sugarcane was found to be significantly influencing the sugarcane supply with the expected positive sign of the coefficient (p=0.025). This means that the area allocated to sugarcane is positively impacted by an increase in the real sugarcane price in the immediate preceding period. The coefficient (0.954013) was however, less than unity implying that the own-price elasticity of sugarcane supply was inelastic in the short-run. This means that when the price of sugarcane increases the area allocated to the crop is likely to increase in the subsequent period but the increase in land allocation is relatively lower than the price change. These obtained results compare close with the ones obtained by Mutua (2015) who obtained a short run own price elasticity of 0.64 for sugarcane out-growers in Kenya.

The price of the rice was found to have significant influence on sugarcane supply with the expected negative sign 0f the coefficient (p=0.0623). This means that the area allocated to sugarcane is negatively impacted by an increase in the rice price in the immediate preceding period. The coefficient was, however, less than unity (-0.654929) implying that the rice price elasticity of sugarcane supply was inelastic in the short-run. This means that when the area allocated to the sugarcane crop is likely to decrease in the subsequent period but the decrease in land allocation is relatively lower than the price change.

The coefficient of adjustment (γ) was negative as expected. This is one of the important criteria for the good estimated vector error correction model. The P-vales was found to be

0.0022 which is much less than 0.01 critical value. Therefore we were able to reject the null hypothesis and conclude that the coefficient of adjustment is statistically significant at 1% level. Being negative means that if there is any departure in one direction the correction would have to be pulled back in the other direction so as to make sure that equilibrium is retained. The coefficient of adjustment (γ) being significant means that the explanatory variables granger cause the sugarcane producers acreage (area) response. The coefficient of adjustment (γ) was found to be -0.45387 meaning that about 45% of the departure from long run equilibrium is corrected each period. That is to say the previous periods deviation from long run are corrected in current period at an adjustment speed of 45%.

In the long-run, all the explanatory variables were statistically significant at the 1% level. The coefficient for sugarcane real price was found to be (4.525343) which is positive as it can be seen from Table 7. The P value was found to be 0.0 which was less than 1% level of significance. As a result we were able to reject the null hypothesis at 1% significant level and conclude that the sugarcane real price did real affect the acreage response of the sugarcane out-growers. However the long run coefficient was found to be higher than the short run coefficient, meaning that sugarcane producers are more responsive in terms of acreage in the long run than in the short run. The coefficients had the same signs, positively affecting the acreage planted with sugarcane. The long run own price elasticity was expected to be higher than the short run price elasticity due to the fact that sugarcane is a perennial crop and hence adjustments in area allocated to sugarcane production due to higher prices require significant long-term capital investment (FAO, 2002). This implies that farmers have more flexibility to adjust their land allocation decisions in response to price changes in the long-run as opposed to the short-run. However these results are quite different from those obtained by Mutua (2015) and Mythili (2006) in which the farmers were more inelastic to changes in sugarcane real price with the own price elasticity of 0.72 and 0.26 respectively.

The coefficient of real rice price had the expected negative sign but was elastic (-3.818429). This meant that a one percent decline in the price of rice would lead to a 3.818429 percent decrease in the land allocated to sugarcane in the subsequent period ceteris puribus. The hypothesis of the study, which is rice price has no effect on the supply of cane by sugarcane producers to sugar companies both in the short- and long-run, was therefore rejected for the long-run and the short-run. This implies that sugarcane producers could switch to rice production if rice prices increase and this would widen the sugar deficit gap in the country. The results were different to the ones obtained by Mutua (2015) in which the out-growers had inelastic response both in the short run and long run of 0.32.

The coefficient of sugarcane production in the short-run was 0.506308 which is positive statistically significant (p=0.0025) and long-run coefficient of 0.191547 which is positive and statistically significant (p=0.00). These results suggest that it was inelastic both in the short-run and long-run. Farmers base their expectation of profitability of a given crop on the output realized in the recent past. With better outputs, the profitability of the crop is expected to improve, ceteris paribus. As such, farmers are expected to allocate more land to sugarcane when the output enhancing factors such as higher rainfall, use of yield enhancing inputs like fertilizers and improved planting materials lead to better yields hence more profitability. The out-growers were found to be less responsive in a long-run compared to short-run. Mutua (2015) got similar results in which the coefficient for the amount of sugarcane produced was 0.32 in the long run while in the short run coefficient of the variable was not significant.

The time trend was found to be positive and statistically significant (p=0.000) which was contrary to the expectation. The magnitude of the coefficient was, however, very low (0.013170) suggesting that there was minimal technological change for sugarcane out-growers over the study period. The technological change however seems to have affected the supply response of sugarcane out-growers in the country positively. The technological response is more by the sugarcane farms owned by the sugar companies but the out-growers do not change much in terms of technology. The results differ from those obtained by Mutua (2015) who obtained a negative coefficient of the trend factor of -0.01. This indicates that the Tanzanian sugarcane out-growers are more advanced in technological changes though the change was small.

Table 7: Summarized VECM estimated results for sugarcane out-growers in Tanzania for 1996-2018 period

	Variables	**Coefficients**	**T values**	**P values**
Short run estimates	D(OUTGROWERSAREA(-1))	-0.419561	-2.34247	0.0372**
	D(OUTGROWERSPROD(-1))	0.506308	3.79908	0.0025***
	D(RAINFALL(-1))	0.38848	1.36357	0.1977
	D(SUGARCANEPRICE(-1	0.954013	2.05497	0.025**
	D(RICEPRICE(-1))	-0.654929	-2.55746	0.0623*
	C	0.035417	1.15829	0.2693
Coefficient of adjustment (γ)		-0.45387	-3.86636	0.0022***
Long run estimates	OUTGROWERSAREA(-1)	1.000000		
	OUTGROWERSPROD(-1)	0.191547	2.13502	0.000000*
	RAINFALL(-1)	3.475985	9.60479	0.0000009*
	SUGARCANEPRICE(-1)	4.525343	18.7505	0.00000*
	RICEPRICE(-1)	-3.818429	-20.1467	0.00000*
	@TREND(96)	0.013170	2.80633	0.00000*
	C	40.54613		
R-squared 0.713916				

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The results of the trend analysis show positive correlation between the land area planted with sugarcane, annual sugarcane output and price of sugarcane. This finding suggests rejection of the null hypothesis that sugarcane production and price of sugarcane do not move in the same direction. The data used in the analysis support the alternative hypothesis that sugarcane production and price of sugarcane move in the same direction. The results show that there is decrease in the quantity of sugarcane produced per hectare despite the increase in the area planted with sugarcane. This suggests that out-growers do respond to the sugarcane demand from the industries by allocating more land to sugarcane production.

The VECM results show that both price and non-price factors did have significant effects on out-growers sugarcane supply response in Tanzania during the 1996-2018 period. These findings suggest rejection of the null hypothesis that price and non-price factors do not have significant effect on the out-growers sugarcane supply response in Tanzania. The data used in the analysis support the alternative hypothesis that Price and non-price factors do not have significant effect on the out-growers sugarcane supply response in Tanzania. However, both price and non-price factors were found to be more responsive in the long run compared to the short run. This implies that it takes time for sugarcane farmers to respond to price and non-price incentives. And this makes sense as sugarcane is a perennial crop.

The sugarcane price was found to be positive both in the short run and long run, implying that the sugarcane out-growers would allocate more land to sugarcane cultivation and hence more sugarcane supply to sugarcane manufacturers if there is an increase in sugarcane price. However the sugarcane out-growers were found to be more price elastic in the long run compared to the short run

The real rice price was found to be negative and inelastic in the short run but elastic in the long-run. Rice is the competitive enterprise in most regions that grow sugarcane in Tanzania. Therefore farmers face two choices every season of either to produce sugarcane or rice. These findings suggest that famers are likely to shift to rice production when they find rice to be more profitable than sugarcane, though this analysis is not enough to make such conclusions.

The quantity of sugarcane produced was found to have significant and positive influence on the area planted with sugarcane. This means increase in sugarcane produced would also increase the allocation of land to sugarcane production by out-growers. However, increasing sugarcane production extensification is likely to be detrimental to the environment.

Time trend factor had significant positive effect on area planted with sugarcane during the 1996-2018 period. This implies that there has been improvement in knowledge, awareness, skills and technological advancement in the cultivation of the sugarcane by out-growers. However this improvement is very small as reflected by the magnitude of the time trend coefficient.

5.2 Policy Recommendations

Based on the major findings of this study, the following recommendations are found to be relevant to improve sugarcane production among outgrowers in Tanzania.

(i) The sugarcane produced per hectare was found to be decreasing as the results in chapter four shows. This calls for government in collaboration with agricultural development partners to promote productivity (yield) enhancing interventions including use of technologies such as improved sugarcane varieties, fertilizers, herbicides and irrigation. This should go hand in hand with improving access to government agricultural extension services. Agricultural extension is crucial in enhancing the use of improved agricultural inputs and farming practices such as optimum spacing and timely weeding. Actions taken to improve access to extension should include but not limited to: Increase in the number of extension workers. The number should be based on the intensity of crop farmers or livestock farmers coupled with equipping them will the necessary facilities like means of transport.

(ii) The VECM suggest that the area planted with sugarcane and quantity of sugarcane produced had positive influence on out-growers sugarcane supply. Therefore promoting use of modern tillage implements (tractors and animal drawn) among sugarcane outgrowers. Since tractor ownership is very expensive, its use can be promoted through establishment of tractor hire service centres where farmers can access tractors services at affordable cost.

(iii) The sugarcane real price positively influenced the out-growers' sugarcane supply response. This suggests that sugarcane price is an incentive for farmers to allocate more land to sugarcane production. Sugar producers should ensure more timely payments for cane deliveries and advance payments so as to enable farmers acquire the needed inputs for subsequent seasons.

(iv) The time trend factor was found to be positively affect the sugarcane supply response. However, the magnitude of its effect was insignificant. This suggests that there is need to invest in irrigation infrastructure as a medium-term strategy to improve out-growers sugarcane supply to sugar industries. This will reduce over dependency on rain fed sugarcane production which is seasonal.

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APPENDICES

Post-estimation diagnostics

Appendix 1: Serial correlation

The results for autocorrelation test were as summarized in Appendix, in which the null hypothesis was there is no serial correlation against the alternative hypothesis that there is serial correlation. From the Appendix, it can be seen that the P value was found to be 0.2452 which was higher than 0.05. Therefore we failed to reject the null hypothesis at 0.05 and conclude that we have enough evidence to say that our model had no any serial correlation.

Appendix 2: Summary of the serial correlation test results

Lags	LM-stat	Prob
1	29.45938	0.2452

Appendix 3: Normality test

Component	Jarque-Bera	df	Prob
1	0.798403	2	0.6709
2	0.381319	2	0.8264
3	0.646206	2	0.7239
4	0.018454	2	0.9908
5	0.948183	2	0.6225
Joint	2.792565	10	0.9859

Appendix 4: Heteroscedasticity test

Chi-sq	df	prob
188.9171	180	0.3094