PRODUCTIVITY OF SUGAR FACTORIES IN KENYA

JABUYA DANIEL OTIENO

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DECLARATION

This research paper is my original work and has never been presented for the award of a Degree in any other University.

Signed……………………………….. Date…………………………………

JABUYA DANIEL OTIENO

X50/73059/2014

This paper has been submitted with my approval as the university supervisor.

Signed…………………………………. Date………………………………

Dr. GEORGE RUIGU

(Supervisor)

DEDICATION

This research paper is dedicated to my late parents, James and Penina, my dear wife Rachel, son Jeff and daughter Karmen.

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The views expressed in this paper are my own and do not represent the views of any of the named person(s) and/or institution(s). I solely bear the responsibility for any errors and/or omissions.

Finally to the Almighty Lord for the gift of life and wisdom that has enabled me to complete this course.

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LIST OF ABBREVIATIONS

AFFA	Agriculture, Fisheries and Food Authority
COMESA	Common Market for Eastern and Southern Africa
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
EFFCH	Efficiency Change
FTA	Free Trade Area
KACC	Kenya Anti-Corruption Commission
KALRO	Kenya Agricultural and Livestock Research Organization
KESREF	Kenya Sugar Research Foundation
KSB	Kenya Sugar Board
KSI	Kenya Sugar Industry
MPI	Malmquist Productivity Index
MT	Metric Tonnes
SFA	Stochastic Frontier Analysis
TC	Technical Change
TC/Ha	Total Cane per Hectare
TC/TS	Total Cane/Total Sugar

TCD	Total Cane per Day
TFP	Total Factor Productivity
TFPG	Total Factor Productivity Growth

ABSTRACT

This research estimated the productivity of sugar factories in Kenya for the period 2004 – 2013. Productivity changes were calculated using Data Envelopment Analysis (DEA) approach. The study was done in two stages; the first stage measured productivity changes and decomposed Total Factor Productivity (TFP) growth into its components while the second stage examined the exogenous factors that affected TFP growth. A decomposition of the TFP measures was done to assess whether the change in TFP was caused by either changes in technical efficiency or changes in technical change. The study further examined the effect of market share, cane quality, factory age, size of the industry and ownership structure on productivity changes among sugar factories. The results suggested that the mean TFP growth index for the period 2004 to 2013 was 0.15%, technical efficiency growth index was 11.48% and technical change index was -5.12%. The study results suggested that sugar factories were facing productivity growth problems as TFP growth generally remained constant. TFP growth was mainly influenced by technical change. Government ownership of firms and increase in factory age negatively affected TFP growth while improvement in cane quality increased TFP growth. Market share and number of factories in the industry were not significant determinants of TFP changes. The study recommended privatization of state owned sugar factories and improvement of technical change index through technology adoption and innovation.

CHAPTER ONE

1.0 Introduction

This chapter describes the background information, location and structure of the sugar factories in Kenya, role of the sugar industry, performance of the sugar factories in Kenya, challenges facing the Kenyan sugar industry, reforms in the sugar industry, the research problem, objectives of the study, significance of the study and organization of the study.

1.1 Background Information

Kenya's economy is mainly dominated by the agricultural sector even though only 10% of the total land area receives adequate rainfall and is able to sustain agricultural activities. Approximately fifty per cent of the total output generated from agriculture is meant for domestic consumption (subsistence production). The contribution of the agricultural sector to Kenya's Gross Domestic Product (GDP) is only second to the service industry. Tea and the horticultural industry are the key determinants of growth in the agricultural sector and the most valuable among Kenya's exports. Growth of productivity in the agricultural sector positively influences the growth of an economy. To enhance Kenya's economic growth and development, it is therefore important to improve agricultural productivity (Nyoro, 2012).

Sugar cane is one of the industrial crops of Kenya. The sugar industry in Kenya has made a major contribution to the development of the nation. Despite its key importance to the economy, it has continued to perform dismally leading to persistent deficits in production. There poor performance puts at risk the livelihoods of over 250,000 small scale farmers who depend on the sector. Lack of productivity growth in the sector is attributed to various factors including inadequate supply of sugar cane to factories; cane poaching; low levels of capacity utilization; lack of technological progress and poor managerial capacities (KSB, 2011).

The Kenya's manufacturing industry, in which the sugar sector belongs, has remained stagnant in its contribution to the GDP. The contribution has remained at an average of 10% for more than ten years (Kenya Economic Survey, 2015). The Kenya vision 2030 stipulates that the sector should account for 20% of the GDP. Achieving this goal requires that some underlying constraints that hinder faster growth are addressed. They include high input costs, decline in investment portfolio, high cost of credit and competition from imports.

Productivity can be defined as a general increase in outputs resulting from conversion of inputs to outputs in the process of production (Shih-Hsun. et al., 2003). Therefore estimates of productivity may be examined collectively (across the economy) or in specific industries using different measures. Efficiency in production is generally used as a measure of performance of a firm/industry by comparing the amount of inputs used in the production of output while minimizing wastage of resources in the production process.

Improved productivity leads to higher economic growth, creation of wealth and new job opportunities, higher revenue generation through taxes and better living standards in a country. Higher productivity enhances the viability and profitability of firms in an economy. This makes productivity to be a major determinant of competitiveness (Magati and Muthoni, 2012). To improve Kenya's economic growth and development, there is need to improve productivity across all sectors of the economy (Kenya Vision 2030). Measurement of productivity of various firms and industries in the economy should be done regularly to assess their level of competitiveness.

1.1.1 Location and Structure of the Sugar Industry

Sugar cane is mainly grown in the former western and Nyanza provinces. The crop is also grown in parts of Nandi, Kericho and Narok, Kwale and Tana-River counties. About 90% of the total sugarcane production is contributed by small scale farmers. Sugar cane production from large scale farmers and farms owned by sugar factories (nucleus estates) accounts for 10% of the total production (KSB 2003). This is in contrast to other COMESA countries where plantations owned by sugar firms (Nucleus) account for at least 60% of total cane production.

The industry has eleven operational sugar factories namely: Chemelil Sugar Factory; Kibos Sugar and Allied Factories; Muhoroni Sugar Factory (in receivership); Mumias Sugar Factory; Nzoia Sugar Factory; Soin Sugar Factory; South Nyanza Sugar Factory; Sukari Industries Limited; Transmara Sugar Factory; West Kenya Sugar Factory and Butali Sugar Factory. Kwale International Sugar Company is yet to be commissioned (Kenya National Assembly: March, 2015).

Sugar cane farming was first introduced in Kenya in the year 1902. The first sugar processing factory was established at Miwani near Kisumu in 1922 and later Ramisi in the then Kwale District in 1927. Due to increase in demand for sugar, the government later got widely involved in sugar production through additional investments in sugarcane growing schemes and factories; Muhoroni (1966), Chemelil (1968), Mumias (1973), Nzoia (1978) and South Nyanza (1979). West Kenya (1979), Butali (2010), Kibos (2008), Soin (2008), Sukari (2011) and Transmara (2011) are privately owned sugar companies.

The Kenyan government involvement in the sugar sector was influenced by the need to address sugar consumption needs of the country through self-sufficiency in sugar production. Sugar production was introduced to reduce overdependence on sugar imports and save foreign exchange on sugar imports. It was also expected to accelerate development by improving the livelihoods in the rural areas through employment and wealth creation (Sserenkuma and Kimera, 2006).

The Kenya Sugar Directorate under the AFFA is the regulatory body of the Kenya Sugar Industry. It is responsible for regulating, developing and promoting the Kenya Sugar Industry. The Sugar Research Institute (RSI) under the Kenya Agricultural and Livestock Research Organization (KALRO) conducts research on sugar cultivation and production by developing appropriate and suitable technologies.

1.1.2 The Role of the Sugar Industry in Kenya

The sugar industry in Kenya greatly contributes to social and economic development of the country in addition to enhancing the growth of Gross domestic product (GDP). There are more than 250 000 small scale sugar cane farmers in Kenya who depend on the industry. The Kenya Sugar Board estimates that approximately six million Kenyans rely directly or indirectly on the industry as their main source of livelihood (KSB, 2011).

The industry generates revenue to the government through taxes. The industry has also contributed immensely in infrastructure development through road construction and maintenance of bridges as well as provision of social amenities such as education, health, sports and recreation facilities.

The by-products of sugar manufacturing are a source of raw materials for other industries. They include bagasse (cane residue) used for power co-generation and molasses which is used for industrial production of ethanol. Sugar is an important food item and also a critical raw material in food, beverage and pharmaceutical industries. The industry has immensely contributed to the development of urbanization through emergence of towns near sugar factories.

1.1.3 Performance of the Sugar Industry

Kenya has been experiencing a steady rise in the domestic demand for sugar. The gap between sugar production and consumption has continued to increase making Kenya a net importer of sugar.

Area under Cane

The area under cane grew from 95,279 hectares in 1984 to 213,920 hectares in 2013.Theincrease in area under cane is due to high cane demand because of new mills and expanded capacity of most sugar factories. However, the increase in area under cane has not translated to self-sufficiency in sugar production (KSB 2001 and 2013). This is due to increase in small scale growers who have autonomy in their operations. This leads to adoption of diverse farm practices which contribute to low sugar cane yields.

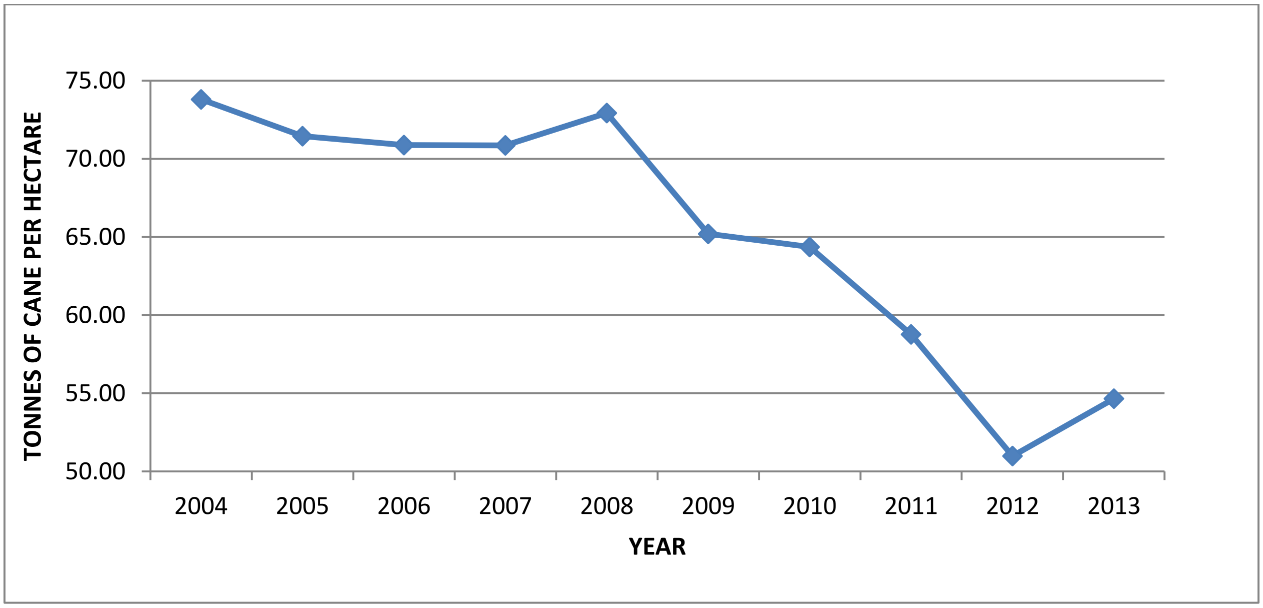
The Area Harvested

The largest area harvested was recorded in 2012 when 87,340 hectares of cane was harvested. However the best industry performance during the study period was achieved in 2010 when 49.83 per cent of the area under cane was harvested (KSB, 2013).Kenya harvested an area of 77,000 hectares in 2011 which yielded 501,473 MT of sugar while Zimbabwe harvested 37,500 hectares from which it produced 430,000 MT of sugar, an indication of serious disparity in sugar production between the two countries. Kenya's sugar sector continues to perform dismally in comparison to COMESA countries.

Cane Yields

The average cane yield in Kenya during the period is 65.4 TC/Ha. This is very low compared to other COMESA countries like Egypt 126.4 TC/Ha, Zimbabwe 93 TC/Ha, Tanzania 85 TC/Ha and Malawi 113 TC/Ha. Low yields are attributed to poor cane husbandry, high costs of farm inputs and low yielding cane varieties (MAFAP, 2013).

Figure 1: Average Sugar cane yield, Tonnes/Ha 2004-2013



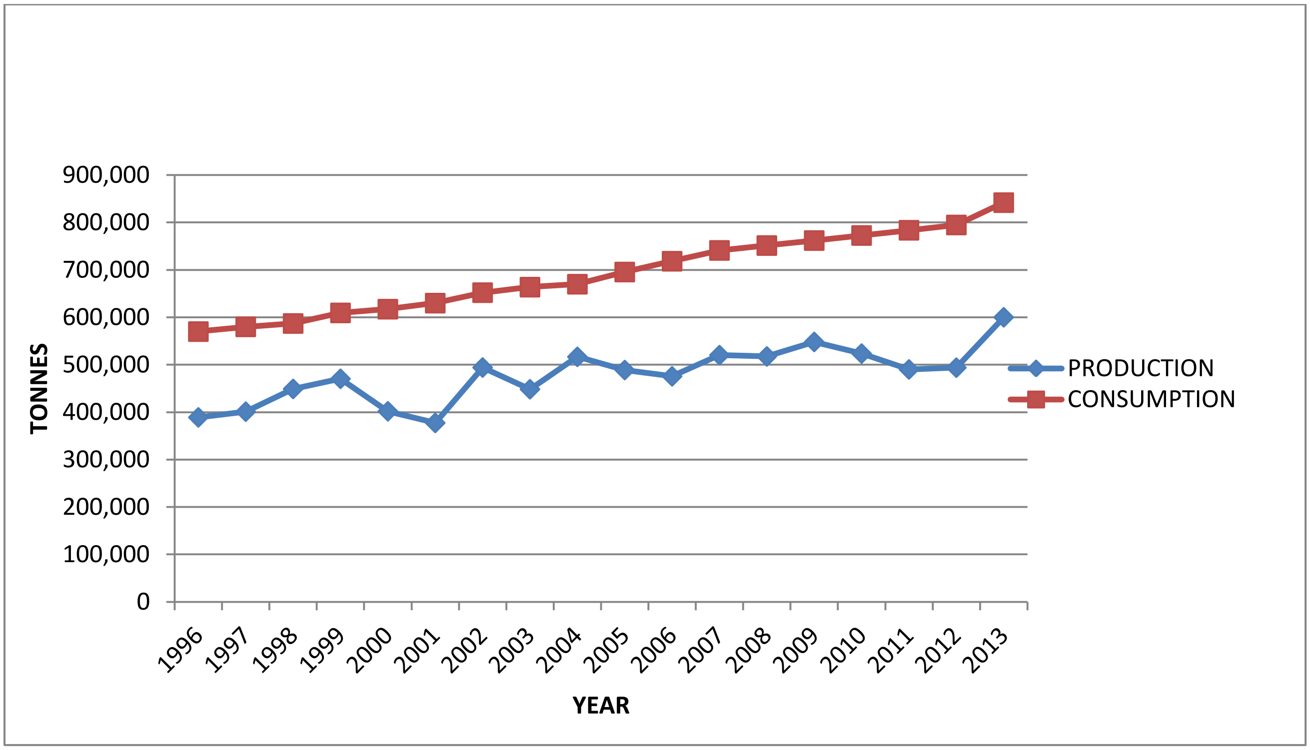
Source: Generated by the author from KSB data

As can be seen in Figure 1, the average cane yield in MT per hectare for the industry declined steadily from 73.8 TC/Ha in 2004 to 51.00 TC/Ha in 2012. This negatively affects sugar production by the factories.

Sugar Production

Sugar production in Kenya has grown from 389, 138 MT of sugar in 1996 to 600,179 MT in 2013. During the same period, the quantity of sugar consumed increased from 570,000 MT in 1996 to 841,957 MT in 2013 (KSB, 2013). The deficit in meeting domestic sugar consumption needs from local production has grown from 180, 862 MT in 1996 to 241,778 MT in 2013. This has made Kenya to regularly import sugar to meet the domestic demand for sugar (KSB, 2013).

Figure 2: Local Sugar Production compared to Estimated Sugar Consumption in 1996 to 2013



Source: Generated by the author from KSB data

According to Figure 2, the gap between sugar production and consumption has continued to increase. Since the cost of producing sugar in Kenya remains high, the trend is expected to continue unless the efficiency and productivity of sugar factories is improved.

Cane Quality

The Quality of sugar cane crushed measured as pol % cane (sucrose content) has been steadily decreasing from 13.28 in 1996 to 11.16 in 2013 against an industry target of 13.50. This is low compared to other countries in the region like Malawi with 14.26.The low sucrose content is due to poor cane varieties, fluctuating weather patterns and lack of coordinated extension services.

Capacity Utilization

The combined installed capacity of all sugar factories in the country is 30,866.4 TCD. This could produce approximately 1,187,910.08, MT of sugar per year leading to surplus sugar production of over 300, 000 MT. However during the period, the average capacity utilized was 19 239.33 TCD (59.535%). Moreover, the low capacity is attributed to unscheduled factory stoppages, factory breakdowns and lack of cane for grinding by the sugar factories (KSB, 1999 and 2006).

Product Diversification in the Sugar Industry

Kenyan sugar factories rely on sugar sales as their main source of revenue. It is only Mumias which has diversified to power co-generation in which 26MW of the 38MW generated is supplied to the National Grid. In addition to electricity, Mumias produces 22 million litres of ethanol and 15 million litres of bottled water (Kenya National Assembly; 2015). Unlike Kenyan firms, sugar firms in the COMESA region have diversified their operations to reduce over reliance on sugar sales as a source of revenue. Challenges to product diversification in Kenya have been due to lack of competitiveness of the industry’s products; old factory equipment/machinery, low factory capacity and poor laws governing the operations of the industry (KSI, 2010- 2014, KSB 2007).

Sugar Imports and Exports

Kenya's sugar exports decreased from 24,478 MT in 1996 to 11,580MT in 2004. From 2004 sugar exports decreased further to 104 MT in 2013. In contrast, sugar imports have steadily increased from 65,816 MT in 1996 to 238,046 MT in 2013.The decrease in sugar exports is mainly due to relatively higher domestic ex-factory prices. The increase in imports is as a result of increase in sugar demand and a deficit in local sugar production (KSB, 2013).

Table1: Sugar Production and Trade in Kenya (2008 – 2013)

Item	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Mean**
Production (MT)	517,667	548,207	523,652	490,210	493,937	600,179	528,975.33
Imports (MT)	218,607	184,531	258,578	139,076	238,589	238,046	212,904.5
Exports (MT)	44,332	1,952	47	16,716	434	104	10,597.5
Self-sufficiency ratio (%)	70.31	74.81	66.94	77.90	67.43	71.60	71.50
Import dependency ratio (%)	29.67	25.18	33.05	22.10	32.57	28.40	28.50

Source: Author's compilation from KSB data

Kenya is a net importer of sugar with an import dependency ratio ranging from 25.18% to 33.05% and a self-sufficiency ratio ranging from 66.94% to 74.81% during the period 2008 – 2013. The mean import dependency ratio during the period was 28.50 per cent against a self-sufficiency ratio of 71.5 per cent, an indication that local sugar production cannot sustain the domestic sugar consumption. Unlike other COMESA countries like Zimbabwe and Zambia, Kenya has not regularly utilized its EU sugar export quota of 11,300 MT due to deficits in sugar production (Monroy et al., 2013).

1.1.4 Challenges facing the Sugar Industry in Kenya

Kenyan sugar factories are high cost producers of sugar. This has reduced competitiveness of the industry (KSB 2007). The cost of sugar production in Kenya is currently estimated at USD 870 per MT which is twice the cost of production in other COMESA competing countries. This is very high compared to Zimbabwe (USD 300), Malawi (USD 350), Swaziland (USD340), Sudan (USD 340), and Zambia (USD 400), (Kenya National Assembly, 2015).

The sugar industry is constrained by low production capacities, lack of clear harvesting schedules, huge debts, managerial inefficiency, cane poaching, unreliable and fluctuating weather conditions, outdated technology, equipment and machinery.

The factories continue to operate at low capacities due to low levels of technical efficiency and managerial inefficiencies (KSI, 2009 and KSB, 2010). The main determinant of the productivity of a sugar factory is the ratio of total sugar cane crushed to total sugar made (TC/TS ratio). This shows the MT of cane crushed to yield one MT of sugar. A comparison of TC/TS ratios between private and government owned factories reveals a significant difference. In 2012, the conversion rate for Butali was 9.74 while Chemelil was 18.41 (KSB, 2013). This means Chemelil had to crush an extra 9MT of cane to produce one MT of sugar like Butali.

Being a member of COMESA free trade agreement, Kenya is bound by the provisions of the free trade protocol that allows sugar imports from COMESA FTA countries to gain access to the Kenyan market without any quota or duty restrictions. This has resulted in an influx of sugar imports whose prices are much lower in comparison to sugar produced in the country. This renders locally produced sugar non-competitive. Most of Kenya's exports end up in the COMESA region from which Kenya earns a lot of benefits through foreign exchange. It is therefore difficult for Kenya to restrict imports from COMESA countries because it is bound by the COMESA FTA protocol (KSB, 2006).

In Kenya, sugar is not exempted from tax like other food items and therefore attracts a VAT of 16 per cent. Sugar development Levy is also charged on the sugar millers at a rate of 4%. Most of the farm inputs are imported and tax is levied on them as well. Kenyan sugar cane farmers do not receive subsidies from the government as is the practice in countries like Egypt. This leads to high cost of production which results to high prices of domestically produced sugar. There have been claims of double taxation in which tax is levied on inputs used in sugar production and excise duty is levied on locally produced sugar before it is allowed into the market. The double taxation has been identified as the cause of high prices for local sugar. Suggestions have been made to classify sugar as a food item like maize and other food crops for it to be zero rated (Monroy et al, 2013).

Corruption remains a major challenge in the management of sugar firms. According to KACC (2010), there are many incidents of corruption in the sector. Due to such cases of corruption amongst institutions within the sugar sub sector, there has been high cases of nepotism and favouritism in the appointment of top managers of sugar factories, biased recruitment and hiring of workers in the factories, high cases sugar theft in the factories and lack of transparency in the approval and disbursement of loans by the Kenya Sugar Directorate. There are allegations that approval and licensing of new sugar factories are done without following the laid rules and regulations as set in the Sugar Act (2001).

1.1.5 Reforms in the Sugar Industry

According to KACC (2010), Kenya suffered the biggest crises to its sugar sector between 1998 and 2001. Most sugar mills suffered serious financial crises which almost resulted in collapse of the industry. The main causes of the crises were managerial inefficiency and unregulated importation of sugar due to liberalization. The government initiated policy reforms to save the industry from collapse. This culminated into the enactment of the Sugar Act 2001, which led to the formation of Kenya sugar Board as a new regulator in the industry. New reforms and policies were initiated and implemented to guide and control the activities and operations of all stakeholders in the industry (Ssrenkuma and Kimera, 2006).

Beginning 2001, the Kenya government has renegotiated COMESA safeguards on five different occasions to give the industry sufficient time to improve its productivity and efficiency. In recent case, Kenya was allowed one year extension effective March 1st 2015 to improve efficiency and productivity of its sugar industry (Kenya National Assembly, 2015).

The operations of the sugar industry are funded through the Sugar Development Fund (SDF). SDF was established in 1992 to extend loans to the industry for factory rehabilitation and cane development. It also provides grants for operations of the Kenya

Sugar Directorate and the Sugar Research Institute in addition to the development of roads infrastructure in the cane growing areas. The Out-grower institutions, Millers, Transporters and Farmers are also eligible for the fund (KSB, 2012).

1.2 Research Problem

Following the expiry of COMESA safeguards in February 2015, Kenya was granted a one year extension effective March 1^{st} 2015 to improve the productivity and efficiency of its sugar industry. Kenya has been successfully negotiating the extension of COMESA safeguards since 2001.The COMESA safeguards allow Kenya to limit sugar imports to a maximum of 350,000 MT per year in order to plug the annual gap in sugar production. However, World Trade Organization (WTO) rules permit a maximum of ten years for such special trade protection measures. Therefore, there is likely to be no future extensions of COMESA safeguards. In such a case, there will be influx of cheap sugar from COMESA countries thus threatening the survival of local sugar industries whose sugar prices are very high. This will put the livelihoods of the over 250,000 farmers and over 6 million citizens who depend on the sector at risk. The study therefore aims to analyze the productivity of sugar factories and investigate the factors contributing to lack of competitiveness of sugar produced by the factories.

Failure to improve productivity and competitiveness of the factories may lead to total collapse of the sector which will make the country to rely on imported sugar as is the case in Ghana. This will expose the country to volatile global sugar prices and forex risk. There will be loss of tax revenue to the government while livelihoods of farmers and citizens who depend on the sector will be at risk. This will negatively affect the government policies on poverty reduction in the sugar growing areas.

For many years, sugar consumption has exceeded sugar production. Most sugar firms have accumulated high debts as they continue to operate with inefficiency leading to low levels of productivity. Therefore, there is an urgent need to address the productivity of sugar production. The study will therefore provide policy makers, industry stakeholders and the sugar factories with empirical information on the productivity levels and factors affecting productivity. This will assist in formulation of necessary policies to address the perennial sugar production deficit.

To come up with possible solutions to the research problem, this study will aim to answer the following questions: (i) How has the productivity of the sugar industry in Kenya changed during the period? (ii)Has there been productivity growth in the industry?(iii) Are there factors affecting productivity changes among sugar factories in Kenya?

1.2 Objectives of the Study

The main objective of the study is to assess the performance of the sugar factories in Kenya in terms of their productivity. The specific objectives are;

(i) To analyze the performance of the sugar factories in Kenya.

(ii) To investigate the factors that explains the productivity in the sugar factories.

(iii) To measure the productivity changes of the sugar factories in Kenya.

(iv) Suggest recommendations to improve productivity among the sugar factories in Kenya.

1.3 Justification of the Study

Most of the studies that have been done in the sugar industry have been on technical efficiency of sugar factories in Kenya. Studies on production efficiency have mainly been done at the grower (farm) level. Very few studies have been done on productivity at the factory level for sugar factories in Kenya.

This study attempts to investigate factory level total factor productivity, its components for the sugar factories in the Kenya and to analyze the changes in productivity among individual sugar factories and the industry during the period. The study will therefore estimate and analyze changes in productivity among the sugar factories and for the industry during the study period. The results and recommendations of this research are likely to be useful in the formulation of policies aimed at improving productivity growth among sugar factories in Kenya. The decomposition of TFP into its components will enable policy makers to trace lagging productivity to particular factors.

Analysis of the productivity of sugar factories in Kenya is very important because of the threat posed to the industry by cheap imports and heightened competition from sugar produced in the COMESA member countries. In order to compete effectively against international sugar producers, the productivity of the factories must be improved.

1.5 Organization of the Study

The research paper is organized into five chapters. Chapter one deals with introduction and gives an overview of the industry, including background information, location and structure of the sugar industry, the role of the industry, performance of the industry, challenges, reforms, research problem, objectives and significance of the study. Chapter two covers the theoretical foundation of productivity measurement, empirical evidence and an overview of the literature. Chapter three describes the theoretical model, specification of the empirical model to be estimated, stages of estimation, description of variables and data sources. Chapter four presents the empirical findings of the study. Chapter five gives a summary, conclusion, policy recommendations, limitations of the study and areas for further study.

CHAPTER TWO

2.0 Literature Review

This chapter has two sections: the theoretical and empirical literature review. The theoretical literature review gives an outline of the theoretical foundation on which the subject matter of the study is based while the empirical literature review is based on the studies that have been carried out on the same or related subjects. The chapter also has an overview of literature reviewed.

2.1 Theoretical Literature Review

Growth in productivity can be defined as a general increase in outputs resulting from the conversion of inputs to outputs in the production process (Shih-Hsun et al., 2003). Emphasis on growth in productivity is enhanced by the recognition that increased productivity will lead to higher production and a sector's contribution to economic growth and development.

The productivity of a firm or an industry is a measure of the relationship between its output of goods and services and inputs used in the production process. Productivity is therefore used as a tool to measure the performance of an economic entity. Increased productivity will be an indicator that the firm or industry is utilizing its scarce factors of production efficiently.

Productivity change can be used for measuring the level of adoption technological improvement in the production process (Chambers, 1988).Productivity can be described in two ways; Partial Factor Productivity (PFP) or Total Factor Productivity (TFP). When productivity is expressed as a ratio of total output to a specific input used in the production, that type of productivity is described as Partial Factor Productivity. It measures the contribution of one particular input to output production while ignoring the contribution of other factors of production. If productivity is expressed as a ratio of total output generated in the production process to a sum of all inputs used, then that type of productivity is described as Total Factor Productivity (TFP). Since TFP captures the role of all production inputs, it is assumed to be the most accurate and reliable measure of productivity.

Efficiency in production is generally used as a measure of performance of a firm/industry by comparing the amount of inputs used in the production of output while minimizing wastage of resources in the production process. The production and consumption of optimal output is called economic efficiency. According to Farrel (1957), the economic efficiency of a production unit is composed of two different efficiency measures; technical efficiency and allocative efficiency. Efficiency is concerned with the relation between scarce input resources (e.g. labour, capital, machinery etc) and either immediate or final outcomes. The physical relationship between input and output is called technical efficiency.

When a firm is able to use production inputs in the right proportions at their prevailing prices, the firm is said to experience allocative efficiency. If the marginal rate of technical substitution between a pair of inputs is equal to the ratio of input prices, then the production process exhibits allocative efficiency. According to Yin (1999), data availability and behavioural assumptions in a study will determine the type of efficiency to be measured.

If a production unit is able to avoid wastage by producing maximum possible output from available input or by using very little input as output production allows, then the firm or industry experiences technical efficiency. Technical efficiency occurs when firms are able to obtain maximum output given the inputs employed in the production process. It involves the transformation of the production function through introduction of new inputs and techniques of production. A technically efficient firm will, therefore be on the boundary of its production possibilities surface. The ratio of the observed output to potential output, given the available technology determines the technical efficiency of an individual firm (Farrel, 1957).

Measurement of Productivity

Productivity can be measured using two main methods; frontier and non frontier approaches. The non frontier approaches include index number and growth accounting approaches while the frontier approaches include those where the production function is stated as a function certain parameters (parametric) and those where a production function is not stated (non parametric). The choice on any particular method to use will be determined by the availability of data and the purpose for productivity measurement.

When the index number approach is used in productivity measurement, all the outputs and inputs are used to calculate one productivity index. The productivity index is used in the measurement of the amount of production inputs used compared to variations in output over a specified period of time. The most commonly used indices in productivity measurement include; the Laspeyres, Paasche, Fisher and Tornqvist indices. The approach does not produce accurate values of productivity because it does not take into account statistical principles and theories. No statistical theory can be used to prove their accuracy in productivity measurement (Diewert, 1992).

Growth accounting is commonly used method for measuring productivity change. The approach assumes that output is produced by applying two production inputs; labour and capital. The labour and capital shares, β_L and β_K are also assumed to be the main determinants of growth in output for labour and capital respectively. Due to its simple nature, the approach is widely preferred in productivity measurement. A number of assumptions have to be taken into consideration for the approach to work. One such assumption is that markets for goods and services should be perfect while labour and capital shares should be equal to the marginal products of labour and capital. The economic agents are also assumed to be maximizing their gains while minimizing their losses through optimal resource allocation to attain equilibrium in the production process. However the main drawback of this method is that parameters are average values and if features of the firms are not homogeneous in all respects like in case where firms are experiencing different technological changes, the approach may not produce accurate and reliable productivity measurement results (Murillo – Zamorano, 2003a,b).

The production frontier approach has been popular in empirical studies of productivity and efficiency. To construct a production frontier, an assumption is made that firms are technically efficient by producing highest possible output from allocated inputs. In the production frontier approach, an efficient production function must be recognized before the significance of an efficiency measure is discussed (Farell, 1957). He suggested two methods: parametric/econometric approach and non parametric/linear programming approach. In parametric approach, the frontier is stochastic and therefore uses the stochastic frontier approach. In non parametric approach, the frontier is deterministic and it uses Data Envelopment Analysis (DEA) approach to measure changes in productivity.

Stochastic Frontier Analysis (SFA) is used in addressing the averaging problem in growth accounting. The method is preferred because it is able to identify efficient values which it uses to develop an efficient frontier of efficient observations. The main importance of this method is its ability to allow for testing of hypotheses using econometric methods. The approach allows assessment of maximum output change subject to of level of inputs making it to be an output oriented measure. SFA is a base or non-orienting measure which means that the assessment of efficiency is not conditional on holding all inputs or all outputs constant. The main weakness of this method is the assumption that the production function and change in technology remains similar across the production units. It also imposes an explicit functional form of the production function and distribution assumption on the data and therefore prone to mis-specification. A major criticism of the method is that it cannot adequately handle multiple inputs and outputs (Mula and Jayamaha, 2011).

Data Envelopment Analysis (DEA) is widely used as a tool for productivity measurement because it does not require any restrictive assumption like the behaviour of economic agents or specification of a production function. Depending on the objectives of a study, DEA method can either be defined based on inputs or outputs. When the input based DEA method is used, we estimate the highest margin by which the variation in input levels does not cause any change in the levels of output produced. The DEA output version estimates the highest possible increase in output while leaving the amount of input used unchanged (Fare et al, 1994).

TFP is the most accurate and reliable measure of the overall productivity in an economy, industry or a firm because it captures the contribution to output by all production inputs. TFP can be estimated using different techniques. The popularity of Malmquist index has grown after Fare et al. (1994) applied the linear programming approach in calculation of the distance functions that make up the Malmquist index. Because of the simplicity and less cumbersome nature of the Malmquist index, DEA is used to calculate the TFP index. DEA allows for breakdown and analysis of effects of efficiency changes and technical changes on productivity growth. Data used in DEA analysis is simple and easier to prepare. Unlike the Stochastic Frontier Approach used in productivity measurement, its application is not restricted by many assumptions. It is important to note that DEA is vulnerable to the effects of data noise. When there are very few degrees of freedom, the results generated by DEA may be affected by challenges of uncommon shadow prices (Coelli and Rao, 2005).

Empirical Literature Review

This sub section presents empirical studies that have been done by researchers who have applied Data Envelopment Analysis in the manufacturing sector, the sugar industry and other related sectors.

Wadud (2007) assessed productivity and efficiency changes among firms in the Malaysian Manufacturing industry. The study estimated productivity growth in the industry for the period 1983-1999. Malmquist Productivity Indices (MPIs) were computed using Data Envelopment Analysis (DEA) which showed that growth in productivity was mainly determined by changes in technical efficiency and technological adoption. The results of the study showed that there was no significant growth in productivity. This was because most firms were operating at low levels of technical efficiency.

Tarimo and Takamura (1998) did a study on sugar cane production, processing and marketing in Tanzania. It reviewed the agronomic, production and marketing aspects of sugarcane in Tanzania by focusing on the main factors associated with variation in production during the previous ten years. The results of the study showed that sugar cane production in Tanzania had shown reduced growth during the mid-1980s but showed slight improvement in early 1990s due to favourable economic situation in the country following trade liberalization. The study concluded that sustained sugar production in the country would depend on improved production technology, marketing and storage infrastructure at factories and regional centres. The study recommended increased investment in research through development of high yielding and disease resistant cane varieties.

Raheman et al, (2009), conducted a study on the Efficiency Dynamics of the sugar industry in Pakistan. The study analyzed the performance of 20 sugar firms using panel data. The study applied Data Envelopment Analysis in which Malmquist TFP index was estimated and decomposed into its components (efficiency and technical change). Two output variables (cost of sales and revenue generated from sales) and three input variables (firm expenses, annual assets and equity capital) were used in the study. The outcome of the research showed that the whole sugar industry had experienced some technology improvement. The effect of technology improvement on productivity was reversed by negative changes caused by inefficiencies in management. The effect of the changes is that productivity remained unchanged indicating a divergent trend between TFP and its components. The research suggested that productivity growth had generally stagnated. The study recommended investments in technical change as it was the main determinant of productivity in the industry.

Amri (2013) analyzed the effects of competition on productivity and its components among manufacturing industries in Tunisia. The main objective of the study was to estimate the effects of competition on productivity changes among firms in the industry. Panel data covering the period 1997 – 2012 was estimated using DEA to generate Total Factor Productivity indices. The TFP indices were decomposed into changes in technical efficiency and technology adoption. The results showed that, the main determinant of TFP was technical efficiency. Technical change which was a second source of TFP growth had a negative role on productivity growth up to the year 2000. The study concluded that competition led to improvements in productivity growth, efficiency change and adoption of new technologies.

Oliveira et al. (2013) conducted a study to evaluate the efficiency of sugarcane production in Brazil using DEA. A total of 17 DMUs was considered in the study for the period (2010 – 2011). The inputs used in the study were; land, raw material, costs of the harvest, loading and transport of sugar cane. The output was taken to be revenue from sugar cane sales. The results of the study revealed that there was a relationship between crop productivity and profit. Six DMUs which were found to be efficient among the 17 DMUs were considered as a benchmark for improving productivity in other DMUs.

Kumar (2014) investigated the efficiency of Sugar Manufacturing firms in India using the DEA approach. Technical and scale efficiencies were calculated for public and private sugar manufacturing firms in the industry for the period (2006 to 2010). The study used a sample of 43 firms which controlled a major portion of the market share. Sales revenue and total profit after tax of a firm during the financial year were taken as the output variables while total cost of sales, total operating expenses and total assets held by the firm during the year were taken as inputs. The empirical results using a five year panel data showed that Indian sugar firms achieved an average technical efficiency of 86-90 per cent. This showed that on the average, firms were operating below the efficient frontier.

Nazmul (2015) assessed the production efficiency of sugar factories of Bangladesh using DEA. In measuring efficiency, the amount of sugar produced was used as the dependent variable (output) while MT of sugar cane crushed and crushing days were used as the input variables. The study results showed that 99.6 per cent of variation in the output variable was explained by the explanatory input variables. Using DEA under a CRS technology assumption led to an average production efficiency score of 0.97 in the sugar firms. This was an indication that, on the average, the firms were 3% off the efficient frontier an indication that output could be increased by 3% using the available inputs.

Odhiambo et al. (2004) did a study on the factors determining growth and productivity in the agricultural sector in Kenya from 1965 – 2001. Sources of productivity improvement were identified through growth accounting approach while the determinants were assessed using econometric techniques. The results of the study showed that most of the productivity growth in agriculture was determined by production inputs; land, labour and capital. Factor inputs did not affect 10% of productivity growth in the agriculture during the study period. Labour contributed48% of the total productivity and was the main determinant of agricultural productivity. The study also revealed that fertility and size of land influenced agricultural productivity. The study further revealed that, climatic conditions and government fiscal policy were key determinants of improved productivity in agriculture.

Mulwa et al. (2009) estimated the productivity growth in small holder sugarcane farming in Kenya using DEA in which TFP scores were estimated and decomposed into efficiency change and technical change. The study used a sample of 95 farmers from three sugar zones, Mumias, Chemelil and West Kenya. The outcomes of the study showed that Mumias had a problem of outdated production technologies which led to a general decline in technological change. Chemelil was experiencing negative growth in efficiency change and technology adoption. Most farmers had not started utilizing available technologies fully leading to a decline in production efficiency levels. This resulted to a downward trend in the adoption of newer sugar cane production technologies. The study indicated that the main cause of slow change in efficiency and lack of technology adoption was land fragmentation where independent land owners were using different farming techniques and methodologies.

Irungu et al. (2008) did a study to estimate the efficiency with which sugar factories were utilizing inputs to generate outputs (technical efficiency). Stochastic Frontier Approach was adopted during estimation. Technical efficiency of sugar factories in Kenya was estimated for the period 1980 – 2007 using panel data. The study further investigated the factors affecting technical efficiency in the sugar mills. The results of the study indicated that all the factories were experiencing negative growth in technical efficiency. The negative change in technical change was continuously shifting the frontier downwards leading to low productivity. The study further revealed that the main determinants of technical efficiency of sugar factories in Kenya were; cane quality determined by sucrose content, the size of the market controlled by a sugar factory and the ratio of capital to labour used in production.

Mulwa (2001) estimated the technical efficiency in sugar processing for the period 1980-2000 using Aigner, Lovell and Schmidt (ALS) 1977 model to investigate the impact of Structural Adjustment Programmes (SAPs) on Mumias Sugar Company. Metric Tonnes of cane produced per year were the dependent variable while capital, labour, cane, chemicals, power and fuel were the explanatory variables. The study used time series data. All the variables except cane were found to be experiencing diminishing marginal returns. Most of the variation in sugar output was explained by cane availability. A unit increase of cane was associated with 0.966 units increment in sugar in the SAP period and 0.964 in the pre SAPs respectively.

Mulwa et al (2007) investigated the impact of liberalization of the sugar industry in Kenya based on technical and scale efficiencies using DEA and SFA. The study mainly focused on Mumias sugar factory as a representative of the sugar industry. The results of the study indicated that liberalization had a negative impact on efficiency change. Using DEA, the technical efficiency levels declined drastically from 100% in 1991 to lower levels of 85.4% in 1997 before picking up again while scale efficiencies largely remained unchanged. The SFA results showed a decline in technical efficiency between periods, 1984-1988 and 1992-1997 with the lowest of 88.5% being recorded in 1998.

2.2 Overview of Literature

The theoretical literature on productivity explains various types of productivity and methods of measuring productivity. Productivity may be discussed using a production function where output is a function of inputs such as labour and capital. Productivity measures are intended to identify changes in the level of production that may not be explained by changes in inputs or the characteristics of the original production process. Growth in productivity holding other factors constant implies improved performance. There are different methods of measuring productivity.

A review of empirical literature suggests that DEA is widely preferred technique in measuring comparative efficiency, productivity and performance across various firms and industries. The use of DEA in evaluating productivity and performance has been limited generally in Kenya. DEA has never been used to evaluate the productivity of sugar factories in Kenya. This is the gap that this study aims to fill.

This study therefore uses DEA to analyze productivity changes of sugar factories through Malmquist index decomposition. It will estimate the factory level total factor productivity and its components, for sugar factories in Kenya by analyzing productivity changes among sugar factories during the study period. The study will then investigate factors contributing to productivity changes among sugar factories.

CHAPTER THREE

3.0 Methodology and Data

This chapter describes the theoretical framework which explains the theoretical foundation, on which the study is based, stages of estimation, model specification, and description of variables, tools of analysis employed in the study and methods of data collection.

3.1 Theoretical Framework

The study will use DEA approach which is based on the work of Farrel (1957). In this approach, the efficiency of a production unit (sugar factory) is estimated by comparing it with the efficiency of other factories in the sample. This is done on the assumption that all factories operate on or below the efficient frontier. Assuming that we have a set showing output y that can be produced by x inputs;

$$P(x) = \{\ y: x\ \ can\ produce\ y\} \qquad (1)$$

Taking time $s$as the initial period, the distance function describing output that can be produced with technology at period $s$can be defined as;

$$d^s(x\ , y) = min\left\{\emptyset\colon \frac{y}{\emptyset}\ \epsilon\ P(x)\right\}(2)$$

When ϕ is minimized, $\frac{y}{\phi}$ increases to the maximum possible value. In this case, the highest possible amount of output that can be produced by a given quantity of inputs is estimated by the distance function. For period t, the final period, the distance function can be expressed as;

$$d^t(x, y)(3)$$

3.1.1 Data Envelopment Analysis

Data Envelopment Analysis (DEA) is an approach which does not require specification of a particular form of a production function. DEA methodology was initiated by Charnes et al. (1978) who built on the frontier concept started by Farrell (1957). The methodology used in this study is based on the work of Fare et al. (1994) and Coelli et al., (1998). The DEA Malmquist Index is used to calculate the total factor productivity growth of sugar firms where each sugar factory in Kenya is treated as an independent entity (Decision Making Unit).

Due to its ability to accommodate many inputs and outputs, DEA differs from simple efficiency ratios. However, it provides significant additional information about how improvements in efficiency can be achieved and the magnitude of these potential improvements. DEA technique defines productivity measure of a production unit by its position relative to the frontier of the best performance established mathematically by the ratio of weighted sum of outputs to weighted sum of inputs. The estimated frontier of the best performance is also referred to as efficient frontier or envelopment surface.

3.1.2Malmquist Productivity Index and its Decomposition

This study uses the Malmquist Total Factor Productivity (TFP) index to examine the productivity changes in the sugar industry in Kenya. By applying the approach of Malmquist (1953), this study will estimate the productivity of sugar factories using output distance functions. To estimate changes in productivity for sugar factories in Kenya, this study will apply the methodology of Fare et al. (1994) while using DEA output approach.

With reference to a similar technology, the Malmquist productivity index estimates the productivity change between two data points by calculation of the distances at each data point. Its major benefits are that price data are not required and the TFP indices maybe decomposed into two components; technical efficiency change (firms getting closer to the frontier) and technical change (shifts in the frontier itself).

Distance functions are used to define the Malmquist index. They allow a description of a multi-input or multi-output production technology without the specification of a behavioural objective (such as cost minimization or profit maximization). Distance functions can either be input oriented or output oriented. An input distance function describes the production technology by looking at proportional reduction in input usage; while output is held constant. An output distance function considers a maximal proportional increase in outputs with inputs held constant. Under the assumption of CRS, the two measures will generate equal value while under VRS; the results will vary (Fare et al., 1994).

If period t technology is used as the reference technology, the Malmquist TFP change index between period s (base period) and period t can be written as:

$$m_0^t\left(y_s, x_s, y_{t,}\ x_t\right) = \frac{d_0^t\ (y_t, x_t)}{d_0^t(y_s, x_s)} \qquad (4)$$

If the period s is used as the reference technology, then the Malmquist index will be defined as:

$$(y_s\ , x_s\ , y_t\ , x_t) = \frac{d_0^s\ (y_t, x_t)}{d_0^s(y_s\ , x_s)} \qquad (5)$$

The two indexes appear to be identical in the above illustration. The above two output based productivity indicators will generally produce different productivity indicators unless the reference technology is Hicks output neutral.

To avoid arbitrary choice of benchmark technology or to impose the Hicks output neutral technology as the benchmark technology, Fare et al. (1994) specified the Malmquist Productivity Index by calculating the geometric mean of productivity indices in equations 4 and 5. According to Fare et al. (1994), the Malmquist output oriented TFP change index between period s (base period) and period t (the subsequent period) is calculated as follows.

$$m_0(x_t\ , y_t, x_s, y_s) = \left[\frac{d_0^s\ (y_t\ , x_t)}{d_0^s\ (y_s\ , x_s)} \times \frac{d_0^t\ (y_t\ , x_t)}{d_0^t\ (y_s, x_s)}\right]^{1/2} \ (6)$$

In equation 3, $d_0^s\,(x_t\, , y_t)$ represents the distance from period s observation to period t technology in which y represents output while x represents input. In the interpretation of Malmquist Index, when *m* is greater than 1, it implies that the TFP index has grown between period's s and t. If *m* is less than 1, it implies that TFP has declined. If *m*=1, then there is no change in TFP index.

To show the determinants of productivity changes, Fare et al. (1994) expressed the Malmquist productivity index as;

$$m_0(x_t, y_t, x_s, y_s) = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)} \times \left[\frac{d_0^s(y_t, x_t)}{d_0^t(y_t, x_t)} \times \frac{d_0^s(y_s, x_s)}{d_0^t(y_s, x_s)}\right]^{1/2} \quad (7)$$

When the Malmquist index is expressed in the above format, two important components are derived. The ratio $\frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)}$ measures the change in the output oriented measure of technical efficiency between period *s* and *t*. The ratio inside the bracket measures the technical change which is measured as a geometric mean in the shift in the production technology between the two periods. In the above model, the efficiency change (catching up effect) measures how much close a firm is to the efficient frontier by capturing the extent of diffusion of technology or knowledge of technology use. The technical change (frontier effect) measures the shift or movement of frontier between two periods with regard to the rate of technology adoption or innovation.

The two changes are independent because there can be technical change without efficiency change or there can be efficiency change without technical change. The first ratio inside the square bracket of equation 7 estimates frontier shift for data in final period (t). The second ratio estimates frontier shift for data at the initial period (s).

The changes in a firm's technical efficiency can be decomposed into change due to pure technical efficiency change (managerial efficiency) and changes due to scale efficiency (plant size optimality).

3.3 Model Specification

To calculate the MPI for each of the DMUs, we estimate the four distance functions in equation 7 to obtain the change in productivity between period s and period t. The four distance functions in equation 7 are calculated by solving four DEA-like linear programming problems. According to Fare et al. (1994), the output distance function is the reciprocal of Farell's output oriented measure of technical efficiency.

The CRS linear programming problem under output orientation between the base period(s) and the final period (t) is given as:

$$d_0^t\,(x^{k',t}, y^{k',t})^{-1} = \max \theta^{k\prime} \qquad (8)$$

Subject to

$$\theta^{k\prime} y_m^{k',t} \leq \sum_{k=1}^{K} z^{k,t}\, y_m^{k,t} \qquad m = 1, .., M \qquad (9)$$

$$\sum_{k=1}^{K} z^{k,t} x_n^{k,t} \leq x_n^{k',t} \qquad n = 1\ldots, \mathrm{N} \qquad (10)$$

$$z^{k,t} \geq 0 \qquad k = 1, \ldots\ldots K \qquad (11)$$

We assume that there are $k = 1, \ldots\ldots K$ firms using $n = 1, \ldots N,$ inputs $x_n^{k,t}$ at each time period $t = 1, \ldots, T$. The inputs are used to produce $m = 1, \ldots, M$ outputs $y_m^{k,t}$. θ is an efficiency score for the k^{th} DMU. $z^{k,t}$ is the weight assigned to each DMU to which any particular observation is compared in order to determine the distance to the efficient frontier.

3.4 First Stage Estimation

To investigate productivity change, the values of Total Factor productivity indices are generated through DEA software version 2.1 from which the Malmquist index is decomposed into its components. Equation 7 is the estimable equation in which the ratio outside the brackets measures the change in technical efficiency (EFFCH) between the period's *s* and *t*. The geometric mean of the two ratios inside the square brackets captures the shift in technology (TECH) between the two periods evaluated at x_s and x_t. MPI is therefore the product of efficiency change and technical change. In this stage MT of sugar and molasses produced is used as output variables while MT of cane crushed, actual crushing time and rated capacity will be used as inputs.

3.5 Second Stage Estimation

There are independent variables that may influence productivity in the industry but cannot be controlled by the firms. An OLS regression of TFP scores obtained in stage one is done on a vector of such variables. This is to explain the variation of the TFPCH scores derived from the first stage. A general form of the formula is expressed as;

$$y = f(x_i, \mu) \qquad (12)$$

From equation 12, y is the TFPCH index and x_i, is the vector of explanatory variables. The general relationship between TFPCH and the variables takes the following form;

$$TFPCH = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 P_1 + \mu \qquad (13)$$

Where x_1 is the market share, x_2 is the firm age, x_3 is the cane quality, x_4 is number of firms in the industry and P_1 is a dummy variable for the ownership structure where 1, if government owned sugar firms and 0, if privately owned sugar firms and μ is the error term.

3.6Variable Description and Data Source

The study used secondary data on annual performance sugar factories and the sugar industry in Kenya. The data was collected from the annual year books of statistics published by the Kenya Sugar Directorate and annual Economic Surveys.

Table 2: Definition of Variables

Variable	**Type**	**Description**
Sugar produced	Output	Total MT of sugar produced in one year
Molasses produced	Output	MT of molasses produced in one year
Cane crushed	Input	Total MT of cane crushed in a year
Actual crushing hours	Input	Total actual grinding hours in a year
Rated capacity	Input	Rated capacity of a factory in MT per year
Market Share	Independent Variable	Ratio between a firm's annual sales to industry annual sales.
Firm age	Independent Variable	Age of a factory as at the beginning of the study period (2003).
Cane quality	Independent variable	Sucrose content of the cane crushed in a year
Size of the industry	Independent variable	Number of firms in the industry in a year
Ownership Structure	Independent Variable	Dummy variable 1, if government owned 0, if privately owned

Data on sugar produced, cane crushed, crushing hours, rated capacity, cane quality will be directly obtained from the KSB year books of sugar statistics. Data to calculate market share will be obtained from the KSB year books of sugar statistics. Information on ownership structure, factory age and size of the industry was obtained from the KSB bulletins.

CHAPTER FOUR

4.0 Estimation Results and Discussion

This chapter presents the empirical research findings starting with DEA Malmquist Total Factor Productivity index results and then the second stage DEA regression results.

The study applied the Malmquist productivity index in the estimation changes in productivity for six sugar factories in Kenya. A frontier of efficient performance (best practice frontier) was constructed, Malmquist TFP indices was generated and decomposed into its components (efficiency change and technical change) for each of the six sugar factories and the sugar industry.

4.1 Total Factor Productivity Changes

Table 3: Malmquist Index of all Sugar Factories (2004-2013)

Firm	TE change	Tech. Change	PE change	SE change	TFP change
Chemelil	0.9691	0.9484	0.8641	0.994	0.8209
Muhoroni	0.9395	0.9486	0.9134	0.998	0.8659
Mumias	1.2540	0.9489	1.1557	1.016	1.0972
Nzoia	1.1755	0.9487	1.1197	1.0000	1.0623
Sony	1.1673	0.9485	1.1277	1.0001	1.0673
West Kenya	1.1833	0.9487	1.1525	1.0000	1.0957
Mean	1.1148	0.9488	1.0555	1.00135	1.0015

Source: Author's compilation

In Table 3, an analysis of changes in Total Factor Productivity (TFP) across the six sugar factories showed that Mumias Sugar Factory had the highest growth in TFP at (9.72%) for the study period 2004 to 2013, followed by West Kenya with (9.57%) total factor productivity growth. Sony had (6.73%) while Nzoia had (6.23%) growth in TFP. The worst performing factory is Chemelil (-17.91%) followed by Muhoroni which had a TFP growth of (-13.41%).This means that Muhoroni and Chemelil could still improve their TFP indices by 13.41% and 17.91% respectively with the existing inputs. The negative rate of technical efficiency change shows that both firms were operating below the efficient frontier.

The mean technical efficiency of the six factories is 1.1148.Both Chemelil and Muhoroni were operating below the industry mean at 0.9691and 0.9395. This means the technical efficiency growth of the two firms is negative leading to negative growth in productivity. Mumias had the best mean technical efficiency score (1.2540) followed by West Kenya (1.1833).

Technological change is either positive, zero or negative depending on if it shifts the frontier up, leaves it unchanged or shifts it downwards. The mean technical change for the six factories is 0.9488. The overall rate of technical change among the sugar factories is -5.12%. The negative value of the technological progress implies that it has been shifting the frontier down overtime by an annual rate of 5.12% leading to negative growth in productivity

Table 4: Annual Malmquist Indices of all Sugar Factories (2004-2013)

Period	TE change	Tech. Change	PE change	SE change	TFP change
2004	1.0942	1.0000	1.1092	1.0004	1.1092
2005	1.0478	0.9738	1.0587	0.998	1.0309
2006	1.1298	0.9780	1.0537	0.999	1.0304
2007	1.1052	1.0178	1.0364	1.000	1.0549
2008	1.0915	0.9985	1.0471	1.0001	1.0455
2009	1.0817	0.9276	1.0674	1.000	0.9902
2010	1.1636	0.8854	1.1101	1.000	0.9829
2011	1.0612	0.9420	1.0157	0.997	0.9568
2012	1.1697	0.8793	1.0093	0.998	0.8875
2013	1.2030	0.8851	1.0477	1.000	0.9273
Mean	1.1148	0.9488	1.0555	1.000	1.0015

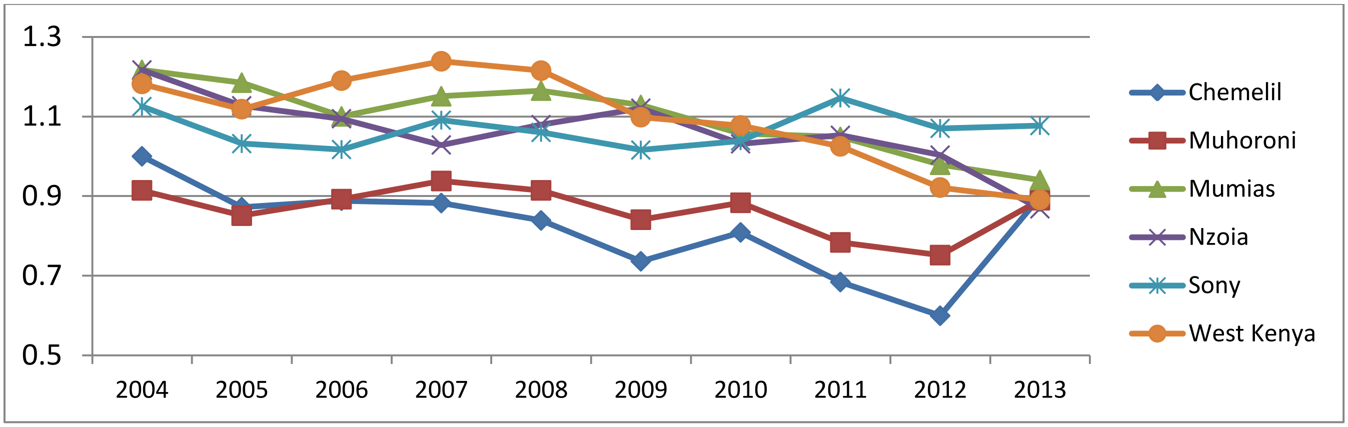
Source: Author's compilation

The results in Table 4 show that TFP growth among the six sugar factories has been showing mixed results. The year's 2004 and 2007 appear to be year's when TFP was highest at 10.92% and 5.49% respectively. The TFP growth was lowest in the year 2012 (-11.25%) followed by 2013 (-7.27%).

Analysis of technical efficiency change during the period shows that year 2013 recorded highest increase in efficiency change (20.3%) while year 2005 recorded lowest increase in efficiency change (4.78%).The mean technical efficiency change across the study period was 1.1148 indicating an increase of 11.48%.

The mean technical change during the study period was 0.9488. This indicates that the overall rate of technical change is -5.12%.The results also show that technical change has a direct relationship with TFP change. A negative overall rate of technical change corresponds to negative growth in TFP during the study period.

Figure 3: TFP changes of Sugar Factories 2004 - 2013



Source: Author's compilation

Figure 3 shows mixed results for TFP changes of the six sugar factories. There is no significant TFP growth recorded by the factories during the study period. This is confirmed by the results in Table 3 where the mean TFP change for the six firms is 1.0015 an indication that TFP grew by only 0.15% which is quite insignificant compared the increasing sugar demand as per the data shown in appendix 1. None of the six factories showed a steady pattern of TFP growth. An analysis of TFP changes for the study period showed fluctuating growth patterns. Year 2013 indicates some form of convergence for the TFP growth in the sugar factories.

Table 5: TFP change in all sugar firms during 2004 - 2013

Firm	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Chemelil	1	0.8087	0.9594	0.9316	0.873	0.6434	0.8451	0.6431	0.5403	0.8733
Muhoroni	0.6886	0.7085	0.8078	0.8479	0.8534	0.7407	0.8732	0.8041	0.93	1.0548
Mumias	1.3784	1.3883	1.2784	1.3583	1.2987	1.3485	1.1786	1.0921	1.0884	1.0783
Nzoia	1.3157	1.1988	1.2365	1.1249	1.1714	1.303	1.2794	1.3142	1.4274	1.359
Sony	1.2717	1.164	1.1732	1.1788	1.0266	1.0483	1.1545	1.4304	1.3049	1.5157
West Kenya	0.544	0.5908	0.9182	0.7305	1.0886	1.1421	1.2323	1.1889	1.0893	1.526
Mean	1.0331	0.9765	1.0623	1.0287	1.052	1.0377	1.0939	1.0788	1.0634	1.2345

Source: Author's compilation

Table 5 shows the TFP changes for each year during the period 2004-2013 and explains the TFP changes for six sugar factories from 2004 to 2013. It helps to analyze and explain the productivity growth of sugar factories in Kenya for each year.

In 2004, Mumias recorded the highest TFP growth of 37.84% while West Kenya recorded the lowest TFP growth of (-45.6%). In the year 2005, Chemelil, Nzoia and Sony showed a decline in their TFP growth while Muhoroni, Mumias and West Kenya showed TFP growth. In the year 2006, all factories recorded TFP growth except Mumias. A comparison of the results of the six factories across the period shows that the performance of sugar factories varies per year without following a definite pattern.

An analysis of productivity changes across the factories showed that, Mumias, Sony and Nzoia have relatively more stable results. The TFP changes in the three factories during the period are greater than unity. Muhoroni and Chemelil Sugar have consistently reported a TFP change less than one throughout the study period. West Kenya experienced positive TFP growth from 2004 to 2010 before dropping in 2011 and 2012. It 2013, it recorded a 52.6% growth in TFP.

The results also show that Mumias has been experiencing a steady decline in its TFP change from 2009 to 2013. This can be attributed to decline in the quality of cane, capacity utilization and actual crushing hours. It can also be as a result of poor management and scale inefficiencies.

A comparison of annual TFP averages for the six factories during the period revealed that the best mean was achieved in 2013 followed by 2005 and 2010. The worst annual mean was recorded in 2007 followed by year 2004.

4.2 Ranking of DMUs

After the first stage estimation, a ranking of all the sugar factories was done based on Malmquist TFP and its components.

Table 6: Ranking of DMUs based on TFP changes

Raking	Sugar factory	TFP change	Overall rate of TFP change
1	Mumias Sugar Factory	1.972	9.72%
2	West Kenya Sugar Factory	1.0957	9.57%
3	Sony Sugar Factory	1.0673	6.73%
4	Nzoia Sugar Factory	1.0623	6.723%
5	Muhoroni Sugar Factory	0.8659	-13.41%
6	Chemelil Sugar factory	0.8209	-17.91%

Source: Author’s compilation

According to Table 6, Mumias Sugar factory has the highest TFP change followed by West Kenya, Sony, Nzoia, Muhoroni and Chemelil in that order. The first two factories are privately owned while the remaining four are government owned. The ranking therefore exposes a disparity in performance between the two categories of factories depending on the ownership structure. Private factories are performing better than the public owned factories.

4.3 DEA Regression Results of TFP Determinants

An OLS regression was carried out to investigate the effects of independent variables on TFP changes. Total factor productivity Change scores was the dependent variable while market share, factory age, size of the industry and cane quality were taken to be the independent variables with ownership structure as the dummy variable.

The model significantly (p-value = .000) explained 86.5% (Coefficient of Determination = .865, R^2 = .930) of the dependent variable, i.e. TFP change.

Table 7: ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1.058	5	.212	69.357	.000
Residual	.165	54	.003		
Total	1.223	59			

Source: Author's compilation

Firm age (p-value = .011), cane quality (p-value = .000) and ownership (p-value = .001) significantly predicted TFP change. The constant, market share and number of firms did not significantly predict TFP change and therefore were dropped from the model.

Table 8: Model Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	.272	.215		1.265	.211
Market share	.123	.069	.124	1.788	.079
Firm age	-.006	.002	-.249	-2.638	.011
Cane quality	.078	.012	.602	6.310	.000
Ownership	-.075	.021	-.248	-3.521	.001
Number of factories	.002	.004	.030	.509	.613

Source: Author's compilation

The general relationship between TFPCH and the variables took the following form;

$$TFPCH = -.006x_2 + .078x_3 - .075P_1 \qquad (14)$$

Where x_2 is the firm age, x_3 is the cane quality and P_1 is a dummy variable for the ownership structure where 1, if government owned sugar factory and 0, if privately owned sugar factory

A unit increase in factory age causes 0.006 units decrease in TPFCH. This was expected because most factories are still using old equipment and machines. A unit increase in cane quality causes 0.078 units increase in TPFCH. This indicates that the cane quality should be improved to enhance the productivity in the factories. Government ownership of a factory causes a decline of 0.075 units in TPFCH. This can be explained by managerial inefficiency associated with public firms. Thus the model implied that increase in a factory's age and government ownership of a factory, causes decline in TPFCH while higher cane quality causes an increase in TFPCH.

CHAPTER FIVE

5.0 Introduction

The chapter presents a summary of the paper, recommendations that can be implemented to improve the productivity of the sugar factories, conclusions that can be drawn from the analysis, limitations of the study and proposed areas where further research can be carried out.

5.1 Summary of the results

The main objective of the study was to assess the performance of sugar factories in Kenya through an analysis of productivity changes. The study also investigated factors affecting productivity in the sugar factories. Secondary data (panel) from the Kenya Sugar Directorate was used in the analysis. By using the DEA Malmquist index approach, the study examined the total factor productivity change of six sugar factories in Kenya whose data was available for the study period (2004 to 2013).

Total Factor Productivity (TFP) was decomposed into technical efficiency component (catching up effect) and technical change component (technology adoption/innovation). The Malmquist productivity index was found to be 1.0015. Its two components, the technological change index was found to be 0.9488 and the technical efficiency change index was found to be 1.1148.

The results of the study showed estimates and pattern of productivity growth among the individual sugar factories in Kenya and also for the sugar industry.

The findings of the study showed that TFP changes showed a fluctuating trend with no significant growth experienced during the study period. The study results indicated that the main determinant of productivity change (growth) was technical change because negative growth in technical change translated to negative growth in total productivity indices.

The effect of market share, firm age, size of the industry, cane quality and ownership structure on TFP changes was examined. The market share and number of firms in the industry were insignificant determinants of TFP changes and were therefore dropped from the model. However firm age, cane quality and ownership structure were found to be significant determinants of TFP changes. Increase in cane quality has a positive impact on productivity changes. Increase in factory age has negative impact on productivity changes which is an indication of old machines, equipment and outdated technology. Ownership structure significantly influences the productivity levels of a factory where government owned firms are performing poorly compared to privately owned sugar factories.

5.2 Conclusions

Since the mean TFP change during the period was 1.0015, this suggests that TFP change has averagely remained constant. The year's 2009 to 2013 when the TFP growth was negative, growth in technical changes were equally negative. The Malmquist TFP results reflect a trend of no significant improvement in the productivity of sugar factories. The overall technical efficiency improved by 11.48% while the technical change had an overall negative effect on productivity by 5.12%. As a result, the overall total factor productivity during 2004 – 2013 remained almost static with an increase of 0.15%.

The negative growth in technical change shows that the frontier is shifting downwards. This shows that an increase in TFP is possible given the production inputs and technology. This could be done by shifting the frontier upwards through technology adoption or innovation.

Regression results of TFP determinants shows that both government ownership of sugar factories and increase in factory age have a negative impact on TFP change while increase in cane quality has a positive impact on TFP change.

5.3 Recommendations

The study results have shown that technical change is the main determinant of total factor productivity growth for sugar factories in Kenya. This study therefore recommends increased research and investment in modern and efficient production technologies. The government should provide subsidies to sugar cane farmers so as to reduce costs of production. Sugar factories should embrace product diversification by venturing into power co-generation, production of ethanol and animal feeds among others. This will reduce over reliance on sugar sales as the main source of revenue. Laws governing the sector should be reviewed to align them with emerging trends, challenges and dynamics in sugar production. Measures should also be put in place to address allegations of rampant corruption in the sector.

The two private factories; Mumias and West Kenya have a higher TFP growth than the government owned millers. This study therefore recommends the privatization of state owned mills so as to improve their efficiency and productivity. The study revealed that cane quality has a significant effect on TFP changes. This study therefore recommends use of improved cane varieties and well coordinated extension services to improve the quality of cane delivered to the sugar factories. This can be achieved by building and enhancing the capacity of the Sugar Research Institute.

Given that an increase in factory age has a negative impact on TFP changes, the study recommends the modernization of equipment and machinery in the four government owned factories to improve their productivity.

5.4 Limitations of the study

The study applied Data Envelopment Analysis which has the advantage of being able to manage complex production environments with multiple inputs and output technologies. However being a non statistical method, it does not produce the usual diagnostic tools with which to judge the goodness of fit of the model specifications produced. Non statistical approaches like DEA have the disadvantage of not assuming statistical noise and given that it is a deterministic method, all the deviation from the efficiency frontier is attributed to inefficiency without considering measurement errors and stochastic fluctuations.

The study only considered six sugar factories among the eleven factories operating in Kenya. This was because the other five factories had been in operation for a period of less than five years and their data could not fit into ten year study period.

5.5 Areas for further study

The effectiveness of market liberalization particularly with the expiry of COMESA safeguards in February 2016 on the sugar industry in Kenya could be analyzed due to the industry's low level of competitiveness. The effects of taxes which are considered high, smuggling/dumping of cheap sugar and the role of cartels in sugar distribution and marketing could be examined. The role of privatization on productivity of sugar factories can be investigated. The effect of corruption on productivity and performance of the industry needs to be investigated.

The role of product diversification in enhancing productivity and performance of the factories could also be analyzed given the experience of Kenana Sugar factory in Sudan and Omnicane Sugar Factory in Mauritius. Further studies could also be done on the effects of over reliance on sugar imports on the sugar factories. The productivity of small holder sugar cane farming compared large scale farming could be studied to assess the impact on sugar cane yields given that over 60% of sugarcane supply to factories within the COMESA region is from large scale production compared to Kenya where 90% of sugar cane delivered to factories is by small scale farmers. The high prices of sugar in the country despite regular sugar imports to bridge the production deficit in production can also be investigated.

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APPENDIX I: Sugar Production, Consumption, Imports and Exports (metric tonnes), 1996-2013

Year	Production	Consumption	Imports	Exports
1996	389,138	570,000	65,816	24,478
1997	401,610	580,000	52,372	25,050
1998	449,132	587,134	186,516	NIL
1999	470,788	609,428	57,701	NIL
2000	401,984	617,270	118,011	2088
2001	377,438	630,065	249,336	3,600
2002	494,249	652,129	129,966	12,046
2003	448,489	663,780	182,225	11,300
2004	516,803	669,914	164,020	11,580
2005	488,997	695,622	167,235	21,760
2006	475,670	718,396	166,280	13,533
2007	520,404	741,190	230,011	20,842
2008	517,667	751,523	218,607	44,332
2009	548,207	762,027	184,531	1,952
2010	523,652	772,731	258,578	47
2011	490,210	783,660	139,076	16,716
2012	493,937	794,844	238,589	434
2013	600,179	841,957	238,046	104

Source: Kenya Sugar Directorate Year Book of Statistics, 2013.