

**EFFICIENCY ANALYSIS OF THE AGRO-PROCESSING INDUSTRY IN  
KENYA**

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## DECLARATION

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

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**DEDICATION**

To

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## **LIST OF ABBREVIATIONS**

CRS	Constant Returns to Scale
DEA	Data Envelope Analysis
DMU	Decision Making Unit
EPZ	Export Processing Zone
F&B	Food and Beverage
KAM	Kenya Association of Manufacturers
KIPPRA	Kenya Institute of Public Policy and Research Analysis
MS	Manufacturing Sector
MTP	Medium Term Performance
SFA	Stochastic Frontier Analysis
TE	Technical Efficiency
TEC	Technical Efficiency Change

## OPERATIONAL DEFINITION OF TERMS

***Allocative efficiency-*** the extent of possible reduction in the cost of producing a specific level of output from using the correct input proportion.

***Efficiency-*** generally describes the extent to which time, effort, or cost is well used for the intended task or purpose.

***Efficiency measure-*** the ratio of actual output to maximum potential output obtainable from a given input level, or the ratio of minimum potential input to actual input required to produce a given output.

***Agro-processing-*** is the process or action taken by manufacturers of converting primary (raw) agricultural products into consumable commodities suitable for consumption.

***Manufacturing-*** refer to the transformation of raw materials (inputs) into finished products that are supplied to consumers and this includes processing.

***Productivity-*** refers to the ratio of output that a firm produces to the inputs that are used to produce that output.

## **ABSTRACT**

This study sought to provide empirical evidence on technical efficiency levels and trend of the Kenya Agro-processing industry. The major problem of the agro-processing industry is that it has been inefficient in terms of value addition to the agricultural produce and Kenya is known to be a net exporter of raw agricultural produce instead of high-quality value-added products. This study sought to determine the efficiency estimates of the agro-processing industry and analyzed the trend in efficiency changes during the period under consideration. Panel data covering three years (2011, 2012, and 2013) for 41 firms in the agro-processing industry was collected from the Ministry of industrialization, Kenya Dairy Board, Kenya Sugar Board, KTDA, KNBS and EPZ departments for the said periods. Econometric production frontiers were estimated for the agro-processing industry in each period. The findings showed that the agro-processing industry had an overall efficiency score of 44 percent. The efficiency score was distributed as 53 percent, 60 percent and 57 percent for the food, beverage, and non-food subsectors. This study concluded that an average 56 percent technical potentiality was not achieved by the agro-processing industry in the period 2011, 2012 and 2013. This study recommends that the policy export promotion of locally processed products of the Kenyan government should be complemented with an industrial policy that enhances the technical efficiency of local exporting firms to increase international competition of Kenyan manufacturers.

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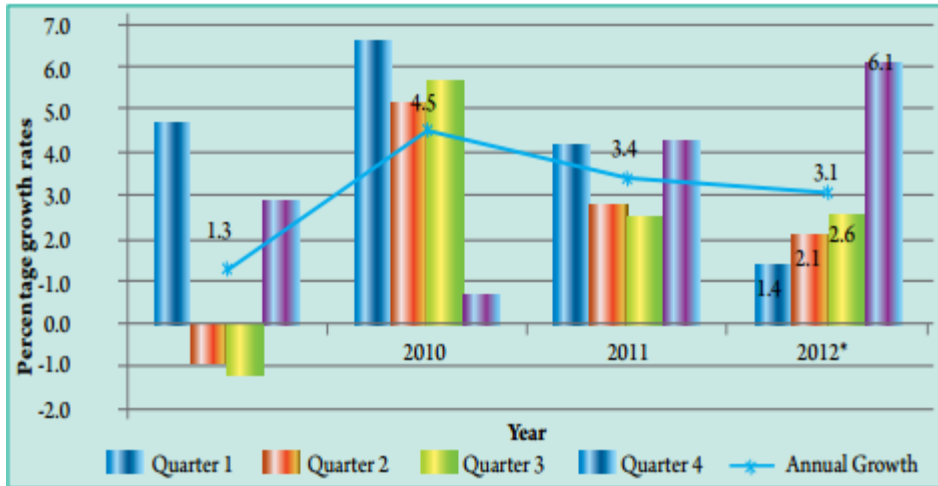
## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1 Background of the study**

Industrial production in Kenya is composed of four sectors. These sectors include: mining and quarrying sector, manufacturing sector, electricity, gas, steam and air conditioning supply sector and water supply; sewerage, waste management and remediation activities sector. This classification is informed by the international standards of industrial classifications of all economic activities (ISIC) Revision 4. The manufacturing sector in Kenya is the largest among all the industrial production activities where it accounts for 99 percent of all industrial activities in Kenya (Kenya National Bureau of Statistics, 2013).

Kenya Vision 2030 identifies the manufacturing sector especially the agro-processing industry as one of the key drivers for realizing a sustained annual GDP growth of ten percent. The Kenya manufacturing sector is made of the following subsectors: building mining and construction(4%), chemical and allied(9%), energy electrical and electronics(6%), agro-processing(38), metal and allied(8%), motor vehicle and allied(5%), paper and board(4%), pharmaceuticals and allied(5%), plastic and rubber(11%), services and consultancy(9%), (Kenya Association of Manufacturers, 2014). The manufacturing sector has high, yet untapped potential to contribute to employment and GDP growth (Government of Kenya, 2013). The manufacturing sectors' average growth percentage has continued to stagnate at three to four percent over the years between 2009-2012.as shown by figure 1.1.



**Figure 1.1: manufacturing sector growth rates, 2009-2012.**

Source: KNBS (2013)

The Kenya manufacturing sector growth was constant over the period 2009-2012, for example from the figure 1.1 growth rates for 2009 was 1.3%, 4.5% in 2010 and 3.4% and 3.1% for 2011 and 2012 respectively. This growth rate is low given that the Kenya Vision 2030 expects the manufacturing sector to grow at a rate of ten percent annually. The Kenya Vision 2030 envisages a robust, diversified and competitive manufacturing sector capable of accelerating employment and economic growth. From figure 1.1, it is evidently clear that the Kenya manufacturing sector growth rates has been low; this has been attributed to global financial crisis, high cost of production and reduced utilization of resources like time and raw materials by the manufacturing firms (Haron and Chellakumar, 2012).

This study was motivated by the performance of the Kenya manufacturing sector, which has remained below the expectations of the Kenya vision 2030 and the Kenya national industrialization policy. This study narrowed down to the agro-processing industry,

since this industry forms the largest component of the Kenya manufacturing sector. The agro-processing industry forms thirty-eight percent of the Kenya manufacturing sector, therefore, efficiency estimates of the agro-processing industry can be used for general conclusions about the Kenya manufacturing sector for the period 2011 to 2013 (KNBS, 2013).

## **1.2 Industrialization policy of the agro-processing industry**

Agro-processing is the process or action taken by manufacturers of converting primary (raw) agricultural products into consumable commodities suitable for consumption. The agro – processing process begins with the main activity of agriculture. Activities such as farming, livestock, horticulture and forestry take place. Thereafter, these raw materials are supplied to manufacturers, who then begin the activity of processing the raw materials through actions such as milling, fermenting, slaughtering, blending, cutting and moldings. The manufactured products are then packaged and supplied to the wholesale and retail markets to be sold to consumers. Agro- processing is a widely diverse subsector and is vital to the production of food, beverages and non-food products like tobacco, sisal as well as the treatment of wood for furniture and paper products (South Africa Small Enterprise Development Agency, 2012).

The National Industrialization policy statement for the agro- processing industry in Kenya seeks to achieve the following six objectives (Government of Kenya, 2010): First, provide incentives for investment in high value processing of agricultural products such as tea, coffee, pyrethrum, cotton, nuts, oil crops, hides and skins, gum arabica, aloe vera and fruit crops such as bananas, pineapples, passion, oranges and mangoes.

Second, promote the local manufacture of agro-processing machinery and equipment's such as tractors, combine harvesters, cotton ginneries, tea picker, juicing and pulping equipment by providing technical information and support for research. Third, encourage clustering of industries around specific agricultural resources for example coconut and cashew nut, honey processing and fish farming and processing. Fourth, promote the processing of biodiesel crops such as sunflower, palm trees, cassava, and jetropha. Fifth, revive 'ailing' rice mills to be in line with the substantial government investment in the sub-sector and promote processing and diversification of rice products and finally to encourage further processing of sugar and sugar products to enhance the competitiveness and productivity of the agro-processing industry.

### **1.3 The current status of the Kenya agro-processing industry**

The agro-processing industry is regulated by: the Ministry of agriculture, which sets the policies and strategies for development of the agriculture sector and sets the policies and strategies for the livestock and fishery industries; Kenya dairy board which regulates the dairy industry and licenses dairy products processors; Department of veterinary Services, a veterinary regulatory management and quality control of inputs, livestock, livestock products and by-products; and the Kenya sugar board, which licenses sugar importation and coordinates the sugar growing industry. Table 1.1 shows the contribution of the agro-processing industry to GDP in millions of Kenya shillings and contribution to wage employment in terms of the total number of people employed by the industry for the period 2011-2013.

**Table 1.1: Contribution of the agro-processing industry to GDP (ksh'000) and wage employment**

	<b>Description</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>
<b>GDP</b>	Total GDP	2,570,334	3,047,392	3,403,534	3,797,988
	Manufacturing Sector	252,122	292,401	321,723	338,378
	Agro-processing industry	79,162	97,053	105,933	113,385
	Manufacturing Sector contribution to GDP	10%	10%	9%	9%
	Agro-Processing contribution to GDP	3%	3%	3%	3%
	Agro-Processing contribution to Manufacturing Sector	31%	33%	33%	34%
	Total wage Employment in Kenya	2,016,200	2,084,100	2,155,800	2,265,700
<b>Employment</b>	Total manufacturing	261,659	270,249	271,026	280,264
	Agro-processing	87,896	89,499	89,991	92,815
	Contribution of Manufacturing Sector to wage employment	13%	13%	13%	12%
	Contribution of Agro Processing Industry to total wage employment	4%	4%	4%	4%
	Contribution of Agro Processing Industry to Manufacture Sector	34%	33%	33%	33%

Source: KNBS (2014)

The manufacturing sector contributed on average 10 percent to GDP and the agro-processing industry contributed on average 3 percent to GDP for the period 2011-2013

as shown by Table 1.1. The manufacturing sector employed 270,249 employees in 2011, 271,026 employees in 2012 and a total of 280,264 employees were employed in 2013 where by an average of 89,319 jobs or (33 percent) were in the agro-processing industry. The total number of all wage employed citizens in Kenya is estimated to be two million citizens. This is a very small section of the Kenya population given that the level of unemployment in Kenya is very high and consequently high poverty levels. Table 1.2, shows the total exports of primary and processed fresh produce in millions Kenya shillings, for the period 2011-2013.

**Table 1.2: Exports of primary and processed fresh produce products (ksh'000)**

	<b>Description</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>
<b>Exports</b>	Total Fresh produce				
	Exported	170,050	195,564	197,094	195,094
	Primary products				
	exported	136,578	153,790	153,197	153,612
	For industry use	18,099	22,448	23,895	18,982
	For household				
	consumption	118,480	131,343	129,303	134,631
	Processed products				
	exported	33,471	41,774	44,293	41,482
	For industry use	4,130	7,158	8,071	5,256
For household					
consumption	29,341	34,616	36,222	36,256	
percentage of total					
products exported as					
processed products	20%	21%	22%	21%	
percentage of total					
products exported as					
Primary products	80%	79%	78%	79%	

Source: KNBS (2014)

The total value of exports of fresh produce products were 197 billion for the year 2012 and a total of 195 billion for the year 2013. Out of the fresh produce products exported only 20 percent of the total products were processed while 80 percent were exported as primary commodities. This shows that value addition to the fresh produce provided by the agricultural sector is very low and consequently little income for the Kenya agricultural industry. This is not a good performance given that Kenya is an agricultural nation involved in the cultivation of food crops, horticulture and livestock keeping (Government of Kenya, 2010). Table 1.3 shows the total imports of primary and processed fresh produce in millions Kenya shillings for the period 2011-2013.

**Table 1.3: Imports of primary and processed fresh produce (ksh'000)**

<b>Imports</b>	<b>Description</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>
	Total fresh produce	70,449	105,967	109,074	101,590
	Primary products imported	31,695	57,398	52,592	48,048
	For industry use	25,949	48,967	43,342	39,624
	For household consumption	5,746	8,430	9,250	8,425
	Processed products imported	38,754	48,569	56,482	53,542
	For industry	9,229	10,719	12,093	8,933
	For household consumption	29,525	37,850	44,389	44,609
	percentage imported as processed products	55%	46%	52%	53%
	percentage imported as primary products	45%	54%	48%	47%

Source: KNBS (2014)

The total imports of 109 billion in 2012 and a total of 101 billion of fresh produce were imported in the year 2013. Out of the total imports, an average of fifty-five percent was processed products. Comparing the imports and exports of processed products, it is clear that imports are greater than exports showing that there is a deficit of processed food and beverages products in Kenya. From the table 1.3 an average of eighty percent of the imported processed food and beverages products are used for household consumption. This is an indication that the Kenya agro-processing industry is not able to meet the demand for processed food and beverages products of the local Kenyans.

#### **1.4 Problem Statement**

To achieve a desired growth rate of 10 percent per year, as envisaged by the Kenya Vision 2030 the government has come up with initiatives to strengthening production capacity and local content of domestically-manufactured goods; increasing generation and utilization of research and development results; increasing the share of locally manufactured products in the regional market; developing niche products for existing and new markets through implementation of Medium Term Performance (MTP) and the national industrialization policy strategies. However, the productivity of the Kenya manufacturing sector and the agro-processing industry has remained below the expected performance. The Kenya Vision 2030 expects the manufacturing sector to grow at a rate of 10 percent annually and contribute 30 percent to the GDP. The contribution to GDP has stagnated at 10 percent and 3 percent for the manufacturing sector and the agro-processing industry respectively over the years and an annual growth rate averaging at 3.16 percent (KIPPRA, 2013, Bigsten *et al.*, 2010, Haron and Chellakumar, 2012).

The amount fresh products from the agricultural sector that are processed by the agro-processing industry have been significantly low making Kenya a net exporter of primary products. Agricultural products form 65 percent of Kenya's total exports and only 20 percent of the total agricultural products exported are processed. This has been attributed to several factors that include: duplication of laws and regulatory agencies; competition from sectorial association; inadequate supplies of raw materials that are seasonal; high production cost with respect to raw material handling, distribution and marketing; slow development and implementation of policies (Bigsten *et al.*, 2010). This notwithstanding, a detailed determination of the actual level of efficiency in the agro-processing industry in Kenya and the distribution of levels of efficiency to the beverage subsector, food subsector and non- food subsector has not yet been done. This study, therefore, attempted to fill this gap by estimating the level of efficiency and analyzing the trend of efficiency in the agro-processing industry over the time period 2011-2013.

### **1.5 Research Questions**

This study sought to answers the following questions:

- (i) What are the levels and the trend of efficiency of the Kenya agro-processing industry for the period 2011-2013?
- (ii) Is there significant difference in efficiency levels at the food subsector, beverage subsector and non-food processing subsector?
- (iii) What are the policy implications of the study's findings to national industrialization policy?

## **1.6 Objectives**

The main objective of the study was to quantify the level of efficiency of the Kenya agro-processing industry for the period 2011-2013 .The specific objectives were:

- (i) To determine the level and the trend of efficiency of the Kenya agro-processing industry for the period 2011-2013.
- (ii) To assess whether there exist significant difference in efficiency level at the food subsector, beverages subsector and non-food processing subsector.
- (iii) To derive the policy implications of the study's findings to national industrialization policy.

## **1.7 Significance of the Study**

This study of efficiency analysis of the Kenya agro-processing industry is essential, given that agriculture is the backbone of the Kenya economy. The need to increase efficiency in the use of resources in the agro-processing industry is important, given that the manufacturing sector contribution to the GDP has stagnated at 10 percent. This study contributed towards providing information on the efficiency levels of the agro-processing industry in Kenya. The understanding of efficiency levels and their implications for agro-processing industry's resource use is one way that could enable development planners and policy makers to determine the current situation, challenges and opportunities of this industry, to enable them to come up with more appropriate ways to allocate resources to this industry and to maximize the returns from the present investment.

## **1.8 Organization of the Study**

This research project is presented in five chapters. Chapter one provides a background to the study while chapter two presents a review of relevant literature, both theoretical and empirical. In chapter three, the methodology that the study adopted, in terms of empirical modeling of efficiency estimation, the variables and their measurements, the type of data used and how the analysis was done are presented. Chapter four presents the findings of the study. In chapter five a summary of the study's findings, conclusions and policy implications are provided.

## **1.9 Scope of the study**

This study analyzed the efficiency of the agro-processing industry in Kenya. The other subsectors in the manufacturing sector were not included in this study due to time and resources constraints. The choice of this industry was made mainly based on considerations that first, the agro-processing industry constitutes the largest portion of Kenya manufacturing sector. Secondly the structure of the agro-processing industry is categorical such that there are three subsectors: the food subsector, the beverages subsector and the non-food subsector. This structure is useful because the analysis of efficiency level were done as per these subsectors.

**CHAPTER TWO**  
**LITERATURE REVIEW**

**2.1 Introduction**

This chapter covers literature review on efficiency. This literature was organized as follows: theoretical literature review, production function theory, approaches to measuring efficiency, empirical literature and overview of the literature are also included in this chapter.

**2.2 Theoretical literature review**

**2.2.1 Production economics theory**

Production economics theory is microeconomics theory, which deals with production of a given output using a set of specified inputs. A production function is used to formalize this relationship. Equation 2.1 is specification of a production function.

$$Y = f\{K, L, R\} \dots\dots\dots (2.1)$$

Where Y represents firms' output, this output is the final processed food, beverages, and non-food products. L represents the amount of labor (people and skills), and R represents the quantity of raw materials used in the production of the Y. The raw materials for the agro-processing industry are the fresh produce from the agricultural sector. K represents the amount of capital employed in the production process; this could be the property, land, equipment and stocks (Varian, 2006).

The objective of the firm is to maximize profit, either by increasing the quantity of Y produced or by reducing the cost of producing Y. The production function shows the

maximum amount of the good that can be produced using alternative combinations of labor (L), raw materials (R) and capital (K).  $Y$  is also referred to as the total physical product (TPP). The marginal physical product (MPP) of an input is the additional output that can be produced by employing one more unit of that input while holding all other inputs constant. The concept of returns to scale shows how output responds to increase in all inputs together. Returns to scale can either be constant, decreasing or increasing (Varian, 2006).

The production relationship can be expressed in several forms such as linear functional forms, polynomial functional forms and Cobb-Douglas functional form. The Cobb-Douglas functional form is modified into the transcendental and translog functional forms. The production frontier refers to a fixed state of technology. If the technology changes, the frontier production function also moves. Positive technological change is a movement towards the origin whereby a given quantity of output can be achieved by utilizing lesser amounts of inputs. Negative technological change is a movement away from the origin (Farell, 1957).

### **2.2.2 The concept of efficiency**

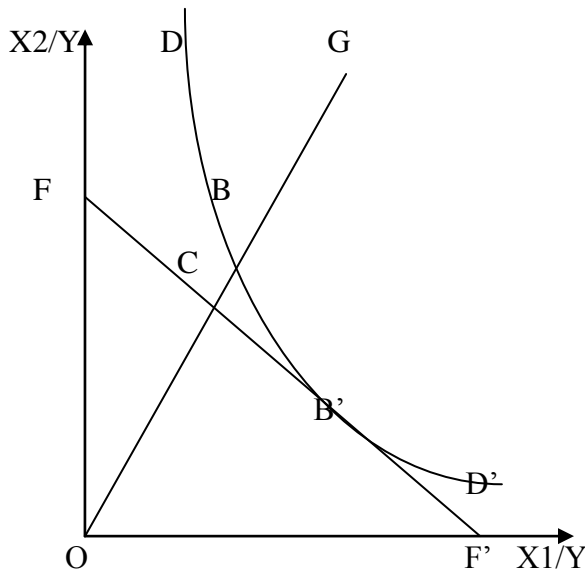
The core of an economic activity is to strive for the maximum possible efficiency or performance. Efficiency is a relative concept, which requires a standard of performance be established against which the success of economics units is assessed (Forsund and Hjalmasson, 1974). The concept of efficiency involves a comparison between optimal values and expected values of output and input of a production line. The comparison

can take the form of the ratio of minimum potential to observed input required to produce a given output or, the comparison can take the form of the ratio of observed to maximum potential output obtainable from given set of inputs. In these two comparisons, the optimum was defined in terms of production possibilities and efficiency was technical. Technical efficiency reflects the ability of the firm to maximize outputs given inputs, (output-oriented) or minimize inputs used in the production of a given outputs. Economic efficiency reflects the production of given outputs at minimum cost or, the utilization of given inputs to maximize revenues or the allocation of inputs and outputs to maximize profits (Kumbahakar and Lovell, 2000).

### **2.2.3. Approaches of efficiency level measurements**

#### **Graphical Approach input and output oriented measures**

Graphical analysis approach can be used to analyze the measure of efficiency based on whether it's input-oriented measure or output-oriented measure. Input-oriented measures explain the extent to which firms and organizations could proportionally minimize inputs to produce a certain quantity of output while output-oriented measures determine output could be increased given inputs. Farrell (1957), illustrated the measurement of efficiency as shown in figure 2.1 using two inputs  $X_1$  and  $X_2$  and a single output.



**Figure 2.1: input –oriented efficiency measure.**

Source: Coelli *et al.* (2005)

The production function of the input-oriented measure was presented as  $Y = f(X1, X2)$ .

Assuming a constant returns to scale production function, so that  $1 = f(X1/Y, X2/Y)$

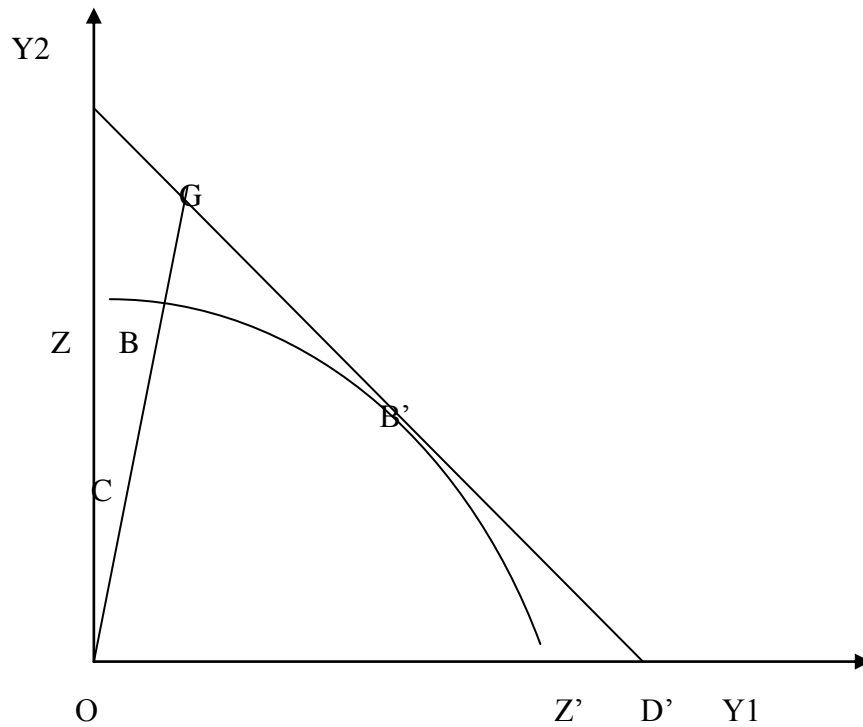
the efficient frontier can be presented as the isoquant ( $DD'$ ) that shows the most efficient combination of the two factors  $X1$  and  $X2$  used to produce a particular level of a product. Any deviations from the frontier  $DD'$  causes inefficiency in the factor use.

The line  $FF'$  is referred to as the isocost curve if a given firm uses quantities of inputs defined by point  $G$ . To produce a unit of output the technical inefficiency of the firm could be presented by the distance  $BG$  (Coelli *et al.*, 2005).

Technical inefficiency is usually expressed in percentage terms by the ratio  $BG/OG$  while the technical efficiency of a firm is measured by the ratio  $OB/OG=1-(BG/OG)$ .

Assuming that all the firms face the same factor prices with the objective to minimize

costs then it is possible to measure allocative efficiency. From figure 2.1 allocative efficiency of the firm operating at point G is defined by the ratio  $OC/OB$  and allocative inefficiency as measured as  $1 - (OC/OB)$ . Combining allocative efficiency and technical efficiency provides total productive efficiency (Forsund *et al.*, 1980).



**Figure 2.2: Output-oriented measures of efficiency.**

Source: Coelli *et al* (2005)

The output oriented measure can be demonstrated by two outputs (Y1, Y2) and single input (X1) which is graphically represented by figure 2.2. ZZ' represents the production possibility frontier where DD' represents the isocost price line. If production is taking place at point G, technical efficiency is given by  $OG/OB$  and technical inefficiency is  $1 - (OG/OB)$ . Allocative efficiency is the measure by  $OB/OC$ ; allocative inefficiency is

defined by  $1 - (OB/OC)$ . The total efficiency is given by Technical efficiency \* Allocative efficiency  $TE*AE = (OG/OB)*(OB/OC) = OG/OC$  (Coelli *et al.*, 2005).

The nearer the ratio moves to unity, the higher the productive efficiency. At B, the productive efficiency will be at the maximum. The weakness of the input and output-oriented measures is that, these efficiency measures assume the production function is known which is not the case. For measurement of efficiency, isoquant must be estimated from the sample data. To overcome this challenge, Farrell (1957), suggested the use of either of the following two approaches to the estimation; first, using a non-parametric piece-wise-linear convex isoquant constructed so that no observed point lies above or below it. Second, using a parametric function, such as the Cobb-Douglas form, fitted so that no observed point lies to the left or below it (Coelli *et al.*, 2005). The first approach led to the development of data envelopment analysis (DEA), and the second one, resulted in use of parametric techniques such as deterministic and probabilistic frontier models. The two approaches are briefly reviewed below, starting with DEA and then parametric ones.

### **Non- Parametric Approach**

The non-parametric approach includes DEA; the objective of the DEA is to measure performance of each producer relative to the best practice in the sample of producers. The main objective is to determine which of the set of producers, as represented by observed data, form an empirical production function or envelopment surface. The producers that lie on the empirical production frontier or surface are deemed efficient, otherwise inefficient (Meeusen and Broeck, 1977).

DEA is characterized by the assumptions that it does not impose a functional form of the production frontier, it does not make assumptions about the error term, and it defines the frontier as the most efficient. It also assumes that the random error is zero so that all the unexplained variations are taken to represent the inefficiency. There are two types of the DEA models referred to as constant returns to scale (CRS) and variable returns to scale (VRS). The appropriateness of either CRS or VRS is determined by economic and other assumptions about the data to be analyzed (Meeusen and Broeck, 1977).

### **Parametric approach**

The parametric approach imposes a functional form of the production function. The functional forms include: the Cobb – Douglas, translog function, constant elasticity function. This approach makes an allowance for stochastic error due to statistical noise or measurement errors. The error term in the model consist of two components as shown by equation (2.2) one that captures the randomness outside control of the firm and the other part is the inefficiency (Schmidt and Lovell, 1979). The deterministic frontier can be specified, in natural logarithms as:

$$\ln y_i = x_i \beta + v_i - u_i \quad i=1, 2, \dots, N \dots \dots \dots (2.2)$$

Where  $\ln y_i$  is the logarithm of the output of the  $i^{th}$  firm,  $x_i$  is a K+1 vector whose first element is value 1 and the remaining elements are the logarithms of K input quantities used by  $i^{th}$  firm,  $\beta_i$  is a K+1 vector of unknown parameters to be estimated,  $u_i$  is a non- negative one-sided error term associated with technical inefficiency (Coelli *et al.*, 2005). Using equation (2.1), the technical efficiency (TE) is given as a ratio of the observed output relative to potential output defined by the frontier function.

$$TE = \frac{y_i}{\exp \beta_i x_i} = \exp(-u_i) \dots \dots \dots (2.3)$$

The ratio (2.2) gives an output-oriented measure of technical efficiency, and its value lies between 0 and 1. The parameters of the model could then be computed via linear or quadratic programming. Linear programming approach entails minimizing the sum of the absolute values of residuals subject to the constraint that this sum is greater or equal to zero. However, the quadratic programming involves minimizing the sum of squared residuals subject to the constraint the sum of squared residuals is greater or equal to zero. Alternatively, the ordinary least squares or maximum likelihood could also be used to estimate the model (Coelli *et al.*, 2005). The major limitation of the deterministic parametric approach is that it does not take into consideration the influence of errors of measurement and other errors on the frontier. All the deviations from the frontier are considered to be as a result of technical inefficiency.

**2.3 Empirical literature review**

Schmidt and Lovell (1979) investigated the relationship between stochastic production, factor demand and cost frontiers. They used a sample of 150 U.S. steam–electric generating plants constructed in the period between 1947 and 1965. They obtained data on output, total cost, and prices of inputs. Capital input was measured in terms of the actual cost of the plant, and labor input was measured in employee man-hours. They estimated a cost function and used the results of the parameters to derive estimates of production function, which was then used to estimate inefficiency. This study is similar to this project on the choice of input and output variables and is different such that a

Cobb-Douglas functional form of cost frontier was used in the estimation while the current study tested a stochastic translog production function for efficiency estimation. Maximum likelihood method of estimation of this study is similar to the method of estimation adopted by this project.

Lundvall and Battese (2000) using an unbalanced panel data for period 1993-1995, estimated a translog production function for the Kenya manufacturing sector. The output variable used in the empirical analysis was the value added of all output produced by the firm in a given year. The input variables consisted of capital which was defined as the replacement cost of existing machinery and other equipment employed in the production process, multiplied by the degree of capacity utilization, Wages which included the total wage bill including all allowances for the firm in one year. This study reported average technical efficiencies of 77 percent, 80 percent, 76 percent and 68 percent for the food, metal, textile and wood subsectors respectively. This project borrowed from this study on the choice of inputs and output variable, their measurements and definition. This study is similar to this project on test of the translog production function as a best fit for the data using SFA but different on the choice of the subsectors in the Kenya manufacturing sector.

Musleh-Ud *et al.* (2007) estimated the efficiency of the large-scale manufacturing sector of Pakistan, using parametric as well as non-parametric frontier techniques. Production frontiers were estimated for two periods—1995-96 and 2000-01—for 101 industries where output of the firms was taken as the dependent variable which was a function of

capital used, labor input and industrial costs. The results showed that there had been some improvement in the efficiency of the large-scale manufacturing sector, though the magnitude of improvement remained small. The results were mixed at the disaggregated level: whereas a majority of industrial groups had gained in terms of technical efficiency, some industries had shown deterioration in their efficiency levels. Musleh-Ud *et al.* (2007) is different since it compared the results of DEA and SFA for two time periods, 1995-96 and 2000-01 while the current study used only SFA in the estimation for the period 2011-2013. This project is similar to this study on the definition and measurement of input and output variables.

Ngui and Muniu (2012), empirically investigated technical efficiency of firms in the Kenyan manufacturing food, metal and textile sub-sectors using data covering two periods: 1992/1993 - 1994/1995, and 2000/2001 - 2002/2003. The stochastic frontier approach was used in the analysis. The likelihood ratio test for specification of technology indicated that with an exception of the textile sub-sector in both periods, the Cobb-Douglas specification was rejected given the translog specification for both food and metal sub-sectors. The dependent variable (output) was measured by value-added in Kenyan shillings. The output was calculated as the difference between gross output and raw materials and indirect inputs in a given period. The results showed that the technical efficiency point varied among the sampled firms in each period. The average technical efficiency of 52 percent, 58 percent, and 60 percent for the food, metal and textile sub-sectors, respectively, imply that nearly 48 percent, 42 percent, and 40 percent technical potentialities were not achieved in the 1992/1993 -1994/1995 period.

On the other hand, the average technical efficiency of 48 percent, 42 percent, and 68 percent for the food, metal and textile sub-sectors, respectively, imply that nearly 52 percent, 58 percent, and 32 percent technical potentialities were not achieved in the 2000/2001 - 2002/2003 periods.

This study is different from Ngui and Muniu (2012), since Ngui and Muniu (2012) used food, metal and textile subsectors estimated a Cobb-Douglas production function using SFA for two time period 1992/1993 - 1994/1995, and 2000/2001 - 2002/2003. While this study used the agro-processing industry and further sub categorized it into food, non- food and beverages subsector and tested a translog production function as the best functional form to fit the data using SFA. Ngui and Muniu (2012) also analyzed the sources of the technical inefficiencies in the manufacturing sector something which the present study did not do due to time and resource constraints. This project not only borrowed from this study on the computation of the output variable and its unit of measurements but also the test of determining the equality of efficiency estimates distribution among various subsectors.

Ghahula (2012) employs Data Envelopment Analysis (DEA) to estimate the relative efficiency of selected 58 commercial banks operating within the East African Community, namely Tanzania, Kenya, Uganda, Rwanda and Burundi from 2008 to 2011. The estimated results shows sharp decline of Technical efficiency. The findings show that most commercial banks in east Africa are operating under a decreasing return to scale. Therefore inefficient utilization of input resources (technical inefficiency)

could be one of the reasons for the inefficiency of commercial banks in East Africa; therefore banks should make use of underutilized resources and reduce operating expenses to be relatively efficient in the production frontier.

Harron and Chelakumar (2012) determined the efficiency performance of the Kenya manufacturing companies over the period of 2009 to 2011. The study also suggested appropriate policies to be employed by the manufacturing companies in Kenya based on the findings of the study. Three critical inputs variables (raw materials, staff expenses and plant and machinery) and two output variables (net sale and earnings after tax) were used to evaluate the relative efficiency of 30 manufacturing companies in Kenya. Data was gathered from Kenya Association of Manufacturers (KAM) database. The results indicated that small-sized company has the highest relative efficiency compared to medium-sized and large size company. In addition, the study finds that 1 large-sized company, 2 medium-sized companies and 3 small-sized companies operate under the most productive scale size throughout the three-year period.

Sudarin and Haung (2013) estimated the efficiency of the food and beverage subsector of Thailand companies, an application of relational two-stage data envelopment analysis. The study used a relational two-stage data envelopment analysis (DEA) to evaluate the efficiency of 23 food and beverage companies in Thailand in 2011. The inputs were cost of sales and services ( $X_1$ ) and other expenses ( $X_2$ ). The outputs were the net profit ( $Y_1$ ) and other comprehensive income ( $Y_2$ ). The conclusion showed that

the low efficiency score of the profit generation process leads to the low overall efficiency score of the companies.

Harron and Chelakumar (2012), Sudarin and Haung (2013) and Ghahula (2012) are similar to this project on the choice independent variables but differ in the method of estimation whereby they used DEA while this project used SFA. These studies specified a Cobb-Douglas production function to represent the frontier function. These studies did not motivate on the choice of rejecting the translog production function in favor of the Cobb-Douglas. The Cobb-Douglas imposes a prior restriction on the firm's technology by restricting the production elasticities to be constant and the elasticities of input substitution to unity. This study specified and tested the stochastic frontier production function using the flexible translog specification (Coelli *et al.*, 2005) based on the log likelihood test of hypothesis on the best functional form to adopt between the Cobb-Douglas and the translog production function.

#### **2.4 Overview of the literature**

The theoretical literature reviewed has given a detailed analysis of the approaches for measuring technical efficiencies of manufacturing sectors using graphical approaches, DEA and SFA approaches. The theoretical literature analysis described the simple approaches to estimation of efficiency by bench marking other DMUs against the best practicing one in the sample. It is evident that the approaches that are currently being used in the estimation of frontiers are broadly classified as parametric and non-parametric. The parametric approach consists of the deterministic and stochastic frontier

models while the non-parametric approach is dominated by the data envelopment analysis (DEA). Besides, there is evidence that both approaches seem to converge on the level of average efficiency, but diverge on scoring individual producers. Schmidt and Lovell (1979) recommended that both approaches be applied to the same set of data on the basis of the strengths and weaknesses of the two approaches, to improve the reliability of the results of efficiency analysis.

Empirical literature reviewed, indicated that technical efficiency of firms can be estimated by either estimating a stochastic production frontier or a stochastic cost function. In the estimation of the production frontiers empirical literature revealed that, both ordinary least squares and maximum likelihood methods were used. Empirical literature reviewed also revealed that the inputs variables used in the estimation of the stochastic production function are mostly labor, capital, and cost of raw materials while the output variables used can be value added and/or return on investments. Apart from Lundvall and Battese (2000) most of the studies reviewed estimated a Cobb- Douglas production function. Empirical literature specific to the efficiency estimation of an agro-processing industry was not available. Therefore, this study contributed towards filling this gap.

## CHAPTER THREE

### METHODOLOGY

#### 3.1 Introduction

This chapter presents the theoretical framework and the model that was estimated in order to provide answers to the research questions. Description and measurement of variables, types of data that was used and their sources, and data analysis techniques that were employed are presented in this chapter.

#### 3.2 Research design

The study utilized a non-experimental research design. The non-experimental design can be further classified into cross-sectional, panel and time series designs. This study adopted the panel design, which involved pooling cross-sectional and time series data. In the design, quantitative research approach was adopted. Quantitative data on the required variables was collected for each of the firms selected. The stochastic frontier function was used in the estimation since this is the model that was available for measuring the efficiency of a productive unit while considering a single output and a set of inputs (Sekaran, 2003).

#### 3.3 Theoretical Model

Suppose a firm uses a set of feasible production plans (inputs)  $X=(X_1 \dots X_N)\in \mathbb{R}_N^+$  to produce a vector of positive net output denoted by  $Y=(Y_1, \dots, Y_M)\in \mathbb{R}_M^+$  in a given time period. A production frontier equation (3.1) is a model used to formalize the relationship  $y = f(x)$ .

$$y_i = f(x_i; \beta) \dots \dots \dots (3.1)$$

Where  $y_i$  is a vector of the output of the  $i^{th}$  firm,  $x_i$  is a K+1 vector whose first element is value 1 and the remaining elements are the K input quantities used by  $i^{th}$  firm,  $\beta_i$  is a K+1 vector of technology parameters to be estimated.

The production function in equation 3.1 is associated with several properties that underpin much of the econometric analysis in this study. First is the monotonicity property, assuming we have two different vector of inputs  $x^1$  and  $x^2$ , if  $x^2$  is greater than  $x^1$  then the output produced by the firms  $f(x^2)$  is greater than  $f(x^1)$  for all  $0 < x^1 \leq x^2$ . The monotonicity property implies that the more the inputs are used in the production process the more the outputs. Secondly, the value of  $f(x)$  is a finite non-negative real number such that it can produce at least zero output and that there is no free lunch. The production of positive output is impossible without the use of at least one input which guarantees that finite input cannot produce infinite output.

The production function is concave; the concavity property of the production function implies that equation (3.1) is continuous, twice differentiable and exhibits constant returns to scale. Finally any linear combination of the vectors  $X^0$  and  $X'$  will produce an output that is no less than the same linear combination of  $f(x^0)$  and  $f(x')$  which confirms the law of diminishing marginal productivity.  $f(x_i; \beta)$  Can take various functional forms including Leontief production function, the Cobb – Douglas, translog function, constant elasticity function the log linear Cobb-Douglas form.

### 3.4 The empirical model

Production function equation (3.1) can be written as a stochastic production frontier used in the estimation of technical efficiency by adding a composite error term  $e_i$ , (see Aigner *et al.* 1977, Meeusen and Broeck 1977).

$$\ln y_i = f(x_i; B_i) + e_i \dots\dots\dots (3.2)$$

$e_i = v_i - u_i$  Is an error term made up of two components:  $v_i$  is a random error having zero mean,  $N(0; \delta_v^2)$  which is associated with random factors such as measurement errors in production and weather which the firms do not have control over and it is assumed to be symmetric independently distributed as  $N(0; \delta_v^2)$  random variables and independent of  $u_i$ . On the other hand  $u_i$  is a non-negative half normal,  $N(0; \delta_u^2)$  random variable associated with firm-specific factors, which leads to the  $i^{th}$  firm not attaining maximum efficiency of production;  $u_i$  is associated with technical inefficiency of the firm and ranges between zero and one. However,  $u_i$  can also have other distributions such as gamma and exponential, (Coelli *et al.*, 2005). The stochastic production frontier given in (3.2) can be extended to the case of panel data, which is specified as:

$$\ln y_{it} = X_{jit} B + v_{it} - u_{it} \dots\dots\dots (3.3)$$

Where  $i = 1, 2, \dots, I$  and  $j = 1, 2, \dots, J$  and  $t = 1, 2, \dots, T$ .  $J$  represents the  $j^{th}$  input of the  $i^{th}$  firm at time  $t$ .  $B$ ,  $v_{it}$  and  $u_{it}$  are the parameters to be estimated. This model gives the time-varying production inefficiency.

$$\ln y_i = \alpha_0 + \sum_{k=1}^3 \alpha_k \ln x_{ki} + \frac{1}{2} \sum_{k=1}^3 \sum_{j=1}^3 \alpha_{kj} \ln x_{ki} \ln x_{ji} + e_i \dots\dots\dots (3.4)$$

This study adopted a panel of three years, Ln denotes natural logarithms,  $y$  and  $x$

variables are defined in Table 3.1.  $\alpha$ 's parameters to be estimated. The stochastic frontier production function could be established from (3.4) in two ways. First, if no explicit distribution for the efficiency component is made, and then the production frontier could be estimated using a stochastic version of corrected ordinary least squares (COLS). However, if an explicit distribution is assumed, such as exponential, half-normal, truncated normal or gamma distribution, then the frontier is estimated by maximum likelihood estimates (MLE). According to Coelli *et al.* (2005), MLE makes use of the specific distribution of the disturbance term and this is more efficient than COLS.

In order to estimate efficiency level of each firm, distribution assumption of  $u$  was assumed to follow the half normal model. Equation 3.4 gives the efficiency estimates and generates variance parameters, (i.e.)  $\lambda = (\delta_u/\delta_v)$ ; variance of the model ( $\sigma^2$ ), variance of the stochastic model  $\delta_v^2$  and variance of the inefficiency model  $\delta_u^2$ . Technical efficiency of an individual firm is defined in terms of the ratio of the observed output to the corresponding frontier output, conditioned on the level of inputs used by the firm. Technical inefficiency is therefore defined as the amount by which the level of production for the firm is less than the frontier output.

$$TE = \frac{y_i}{\exp(\beta_1 x_i)} = \exp(-u_i) \quad i = 1, 2 \dots N \dots \dots \dots (3.5)$$

### 3.5 Definition and measurement of variables

In this study three input variables and one output variable were used. Table 3.1 presents the definition and measurements of the variable.

**Table 3.1: Description and measurements of variables**

<b>Variable Type</b>	<b>Specific Variable</b>	<b>Description</b>	<b>Measurement</b>
<b>Output</b>	Y=Value added	Computed as the gross proceeds from sales of the manufactured products less value added tax and other levy paid by the firms per year.	In Kenya shillings
<b>Inputs</b>	X1=Cost of raw materials	Constituted cost of raw materials, fuels and electricity consumed in the production process per year.	In Kenya shillings
	X2=Labor	Included: salaries and allowances, staff performance bonus, pension defined benefit scheme, provident fund, staff insurance, staff gratuity provision payment of social security fund and leave pay paid to workers per year.	In Kenya shillings
	X3=Capital	Constituted: land, buildings, plant and machinery and other fixed assets which were expected to have a productive life of more than one year and was in use by the sampled firms for the manufacturing activity.	In Kenya shillings

### 3.6 Sampling frame

84 firms were included in the sampling frame; Secondary data for 41 firms was collected for the period 2011—2013. Data for the remaining 43 firms was not available from the secondary sources, and they were left out of the sample. A sample of 41 firms was used for the analysis. This sample formed 50 percent of the total population which was representative of the total population. These data were recorded on an annual basis, where time series and cross-sectional data were pooled to give a sample size of 123.

### **3.7 Data type and sources**

This study utilized panel data. This data was collected from various agencies and bodies including the Ministry industrialization and enterprise development, Kenya tea development agency (KTDA), The Kenya daily board, The Kenya sugar board, the export processing zone departments and the Kenya association of manufacturer's directory. Data was also mined from the annual financial statements and annual reports of firms that are published online by selected firms. The key source documents used for the background of the study was the statistical abstract from the Kenya national bureau of statistics.

### **3.8 Data processing and analysis**

The data on the variables consisting of value added, labor; the cost of raw materials, and capital was verified before analyses were carried out. The analyses were done in accordance with the objectives of the study. First, efficiency levels of the firms were determined using the SFA approach Second, the trend in efficiency levels of the firms was established in the period of the study using the results from SFA approach, Third, the hypothesis of this study was tested and then lastly the difference in efficiency levels of the smallholders within the subsector were carried out.

**CHAPTER FOUR**  
**RESEARCH FINDINGS**

**4.1 Introduction**

The analysis of the collected data was classified into two sections. Section 4.2 presents the descriptive statistics of the sample firms' variables; Section 4.3 presents and discusses the regressions results of the maximum likelihood method and the estimated efficiency levels of the firms.

**4.2 Descriptive analysis results**

**Table 4.1: Summary statistics from sample data**

Table 4.1 presents the descriptive statistics of the variables used in the regression analysis.

Year		Value added	Cost of raw materials	labor	capital
2010/2011	Mean	5,009,600,055	1,228,968,864	617,588,543	1,651,312,438
	Std. Dev.	8,855,682,009	2,938,499,127	1,278,170,293	4,539,431,712
2011/2012	Mean	5,466,779,954	1,350,948,671	718,274,029	1,860,427,599
	Std. Dev.	9,778,766,049	3,356,194,176	1,561,596,274	500,990,157
2012/2013	Mean	6,101,816,444	1,496,712,463	844,166,056	2,052,292,314
	Std. Dev.	11,609,708,104	3,489,491,429	1,990,100,102	5,444,510,003

Source: own calculations.

The figures show that for all the outputs and inputs under consideration the standard deviation was higher than the mean. Harron and Chelakumar (2012) also found the

same in their study. The finding implies that the firms in the Kenya agro-processing industry had a high level of heterogeneity in period under consideration, since the variations were on inputs and outputs; the high standard deviation suggested heterogeneity in the scale of operations by the firms. The Parametric method of efficiency estimation ignores the scale differences among decision-making units (Coelli *et al.*, 2005). Table 4.2 presents the correlation analysis test of the inputs and output of the study.

**Table 4.2: Correlation analysis results**

	Value-Added	raw materials	Labor	Capital
Value-Added	1			
Cost of raw materials	0.6574	1		
Labor	0.7364	0.5432	1	
Capital	0.6624	0.6535	0.588	1

Source: own calculations

Table 4.2 shows that there was a positive correlation between the various inputs and outputs. That is the variables chosen as output and inputs moved in the same direction. This result implies that for the firms to increase their output they had to increase their inputs in the production process. These results also indicated that the independent variables were not highly correlated with each other; therefore, MLE gave unbiased and consistent results.

#### **4.3.1 Regression results.**

The best functional form of the production function to adopt between the translog production function and the Cobb-Douglass production was based on the likelihood

ratio test;  $LR = -2[\ln L_{ur} - \ln L_r]$  where  $\ln L_{ur}$  and  $\ln L_r$  are the maximum values of the log likelihood functions of the unrestricted and restricted model respectively. The results of the log likelihood test statistic were compared with Kodde and Palm critical values as summarized by table 4.3. A simple z-test was used to test the hypothesis that all firms were technically efficient. The test statistic is given by  $Z = \frac{\lambda^{\sim}}{se(\lambda)} \sim N(0,1)$

Where  $\lambda^{\sim}$  is the ML estimator of  $\lambda = \sigma_u / \sigma_v$  and  $se(\lambda)$  is the estimator of its standard error. The test statistics were computed from appendix A1 as summarized by table 4.3.

**Table 4.3: Results of hypothesis testing**

Null Hypothesis	test statistic	degrees of freedom	critical value
$H_0: B_i = B_1 \dots = B_6 = 0$ Translog specification	LR=1.247208	6	11.911
$H_0: \sigma_i = \sigma_1 \dots \sigma_6 = 0$ No inefficiency	$\lambda^{\sim}=6.147163$	6	1.645

Source: Own calculations

Results presented in Table 4.3 indicate that, the first null hypothesis was not rejected hence Cobb Douglas was considered to best represent the data. Ngui and Muniu, (2012), while estimating technical efficiency of the Kenya manufacturing sector also did reject a translog production function, while Kibaara (2005), estimating the technical efficiency of Kenyan farmers accepted the translog production function. Lundvall and Battese (2000) also accepted the Translog specification. The second null hypothesis explored the test that specified that each firm was operating on the technically efficient frontier. This was rejected in favor of the presence of inefficiency effects.

Before proceeding to estimate the Cobb-Douglas production frontier, the panel data was diagnosed for heteroskedasticity and whether it assumed random effects or random effects. F-test was used to test for fixed effects; the LM test was used to test for random effects. Levin, Lin and chu (2002) and Im, Pesaran, and Shin (2003) approach were used to test for the presence of heteroskedasticity, the results were summarized by table 4.4.

**Table 4.4: Diagnostic testing results**

<b>Fixed and random effect testing</b>			
Method	Null Hypothesis	P- value	Decision
F-Test	$Y_1=Y_2=Y_3=0$ Dummies for all the years are equal to zero	Prob > F= 0.8233	No Fixed effects
LM Test	$Var(u_1) = Var(u_2) \dots = Var(u_N) = 0$ variances across entities are zero(No panel effect)	Prob >CHI = 0.000	Random effects present

Source: Own calculations

The results reported in table 4.4 revealed that there were no fixed effects in the data. Random effects were found to be present in the data; this result suggested that inefficiency effects reported in the test of hypothesis table 4.3 were random and not fixed among the firms in the industry. The attempt to test for unit root did not give any significant result; this was attributed to the small times series aspects of the data. Baltagi (2001) notes that heteroskedasticity is a problem to macro-panels.

**Table 4.5: Estimates of the stochastic frontier**

Value added	Coefficient.	Std. Err.	z	P>z
Cost of raw materials	-0.1222	0.0642	-0.35	0.729
Cost of labor	0.488	0.9591	5.09	0
Capital	0.3688	0.1076	2.03	0.042
constant	11.7643	1.9695	5.97	0
/lnsig2v	3.7765	1.0702	3.53	0
/lnsig2u	0.3122	0.2339	1.33	0.0182
sigma_v2	0.0559	0.009		
sigma_u2	1.3105	0.3203		
sigma2	1.3664	0.3196		
lambda	0.9591	0.0119		

Source: own calculations

Based on the data used, the MLEs for the assumed half normal distribution of the inefficiency term in the frontier model are shown in table 4.5. The output from frontier includes estimates of the standard deviations of the two error components,  $\sigma_v$  and  $\sigma_u$ , which are labeled sigma\_v and sigma\_u, respectively. In the log likelihood, they are parameterized as  $\ln\sigma_v$  and  $\ln\sigma_u$ , and these estimates are labeled /lnsig2v and /lnsig2u in the output.

Frontier also reports two other useful parameterizations. The estimate of the total error variance  $\sigma_s^2 = \sigma_v^2 + \sigma_u^2$  is labeled sigma2, and the estimate of the ratio of the standard deviation of the inefficiency component to the standard deviation of the characteristic component,  $\lambda = \sigma_u/\sigma_v$  is labeled lambda.

The signs of the coefficients of the SFA models are consistent with expectations: the coefficients of inputs are estimated to be positive except the cost or raw materials which had a negative coefficient. The result implies that there is a positive relationship between the capital and labor and the output. This result also implies that increasing the raw materials and holding all the other inputs constant the marginal physical product will be less or equal to zero. The results also imply capital and labor are significant inputs in the production process in order for the firms to increase their outputs. The results in table 4.5 revealed that, if all the inputs were to change by the same proportion the output would decrease. This is because the sum of the elasticities of cost of raw material, capital and labor were less than one. This study therefore concluded that the Cobb-Douglas production function estimated exhibits a Decreasing Returns to Scale (DRTS).

#### **4.3.2 Efficiency estimation results**

Table 4.3 presents efficiency estimates for the agro-processing industry for the period under consideration. The mean technical efficiency of the agro-processing industry in Kenya was 44 percent. The efficiency estimates had an increasing trend from 43 percent to 44 percent and 45 percent for the years 2011, 2012 and 2013 respectively. This finding suggested that the industry's efficiency levels were increasing throughout the study period under consideration.

**Table 4.6: Efficiency estimates for the agro-processing industry in Kenya**

<b>Period</b>	<b>Efficiency estimate</b>
2010/2011	0.42732
2011/2012	0.43195
2012/2013	0.44732
<b>Mean</b>	<b>0.435528</b>

Source: Own calculations

Technical inefficiency can be calculated as, technical inefficiency =1- technical efficiency. Therefore the technical inefficiency for the Kenya agro-processing industry was 57, 56 and 55 percent respectively for the years 2011, 2012 and 2013 respectively. This result indicated that the efficiency performance of the Kenya agro-processing industry was below average for the period under consideration, whereby 56 percent of the inputs in this industry were not optimally used to get maximum production from the industry for the period under consideration.

#### **Efficiency distribution among the beverage, food and non-food subsectors**

The agro-processing industry is a diverse industry that can be broadly classified into three main subcategories. This industry is involved in processing, packaging and value addition of the fresh agricultural produce produced through activities of farming, livestock keeping and forestry by the Kenya agricultural sector. Table 4.7 shows the efficiency estimates for the food subsector, beverages subsectors and non- food subsector for period 2011 to 2013.

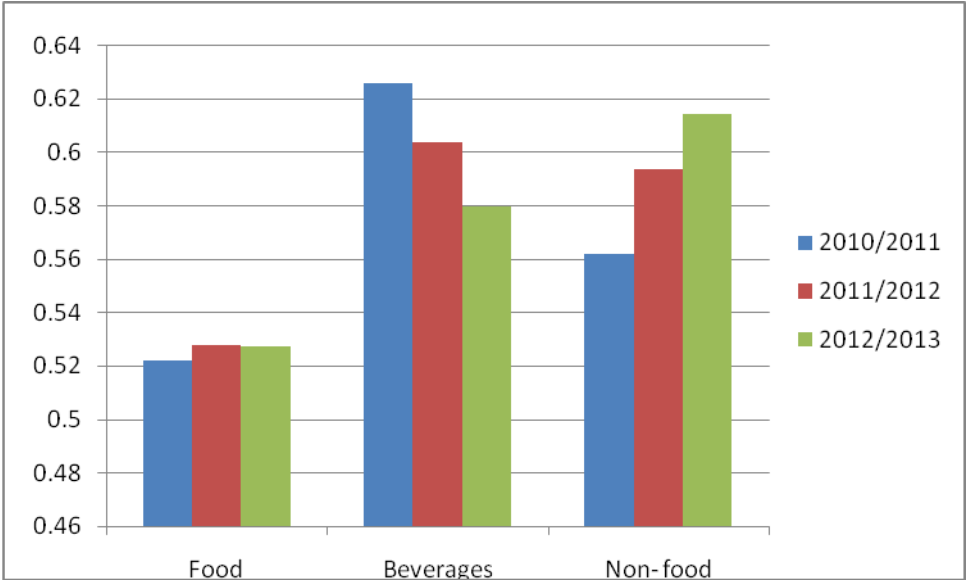
**Table 4.7: Efficiency levels of food, beverages and non- food subsectors**

<b>Subsector</b>	<b>Period</b>	<b>Efficiency estimate</b>
Food	2010/2011	0.522143
	2011/2012	0.527857
	2012/2013	0.527143
	<b>Mean =0.525714</b>	
Beverages	2010/2011	0.626154
	2011/2012	0.603846
	2012/2013	0.58
	<b>Mean = 0.603333</b>	
Non- food	2010/2011	0.562143
	2011/2012	0.593571
	2012/2013	0.614286
	<b>Mean =0.5900</b>	

Source: Own calculations

The mean efficiency estimate for the food subsector was 52 percent for the year 2011 and 53 percent for the year 2012 and 2013. This was an average performance whereby 47 percent of the inputs in this subsector were not being utilized efficiently. The beverage subsector mean efficiency estimate was 63, 60 and 58 percent for 2011, 2012 and 2013 respectively, showing that on average 40 percent of the inputs into this subsector were not being utilized efficiently to achieve a maximum production. The non- food subsector had efficiency estimates at 56, 59 and 58 percent respectively for the period under consideration, This means that on average 43 percent of the inputs into this industry were not being used effectively. Comparing the efficiency levels of the three subsectors the food subsector recorded the least score at 53 percent and then non- food subsector at 60 percent. The beverage subsector recorded the highest efficiency

score. This result suggested that the beverage subsector probably had many big sized firms with high efficiency scores. Figure 4.1 shows the overall trend in the changes in efficiency estimates across the years and among the subsectors, analyzed from table 4.6.



**Figure 4.1: The overall efficiency trend of each subsector from 2011 to 2013**

The results revealed that the efficiency estimates for food subsector were constant, the efficiency estimates for the beverages subsector declined, while that of the non-food subsector had an increasing trend. Increase in the efficiency levels can be attributed to improved management practices over the years, (Lundvall and Battese 2000). This result suggested that the non- food subsector was the best in terms of efficiency improvement for period under consideration.

The findings of this study are consistent with other similar studies on the Kenyan manufacturing sector which found a large potential of improvement among the analyzed firms. For instance Ngui and Muniu (2012) using the subsectors of food, metal and textile and found the efficiency scores to be 52 percent, 58 percent and 60 percent

respectively. Harron and Chelakumar (2012) found that small-sized companies were more relatively efficient with 73 percent as compared to medium and large companies with 68 percent and 69 percent respectively which were higher than the estimates of this study. Lundvall and Battese (2000) reported average technical efficiencies of 77 percent, 80 percent, 76 percent and 68 percent for the food, metal, textile and wood subsectors respectively, which were higher than the estimates of this study. However, in this study the efficiency scores were not directly comparable to those of Lundvall and Battese (2000) and Harron and Chelakumar (2012) since different models were used. Empirical evidence shows that efficiency estimates are sensitive to the estimation or computation methods, assumptions about the distribution of the error terms, data levels and data samples.

**4.3.3: Test for equality of distribution in the efficiency estimates**

Table 4.7 presents the results of K-S test across the years. Two sample K-S test for 2010/11 and 2010/12, 2010/11 and 2012/13, and 2011/12 and 2012/13 was done.

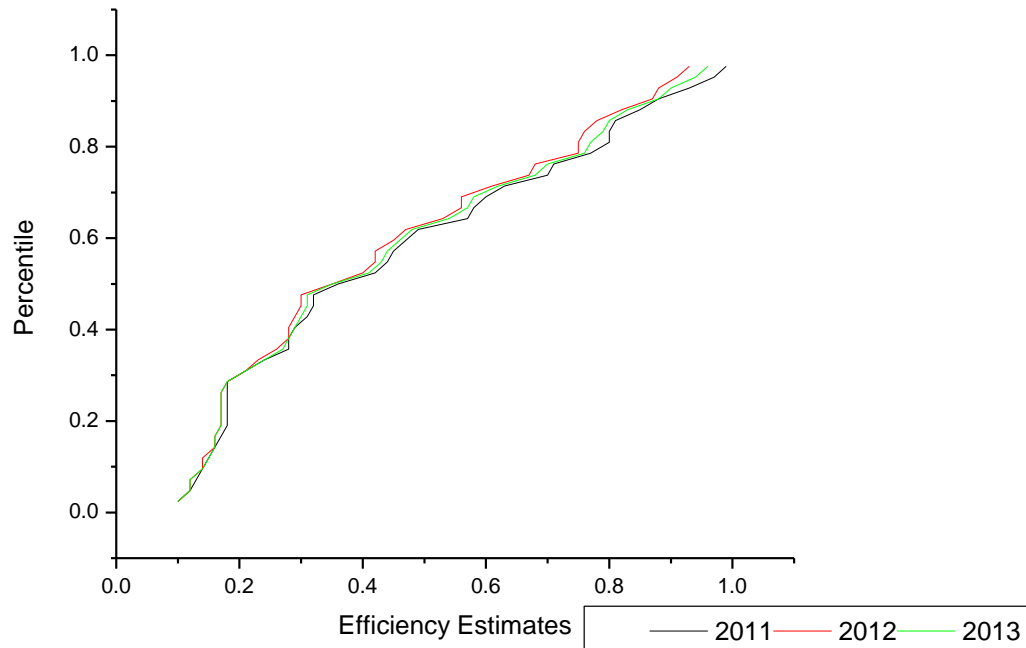
**Table 4.8: Kolmogorov-Smirnov test for equality of distribution in the efficiency estimates**

Period	2010/11	2011/12	2012/13
2010/11			
2011/12	1.000		
2012/13	0.985	0.985	
Probability Values reported			

Source: own calculations

The results revealed no significant difference in the distributions of efficiency estimates for the period 2011-2013 at 5 percent level of significance. This result suggested that

the distribution of efficiency estimates was consistent for period under consideration this result was confirmed by Figure 4.2 which shows the K-S test comparison percentile plot for efficiency estimates time period 2011 2012 and 2013.



**Figure 4.2: K-S test comparison percentile plot for efficiency estimates time period 2011 2012 and 2013.**

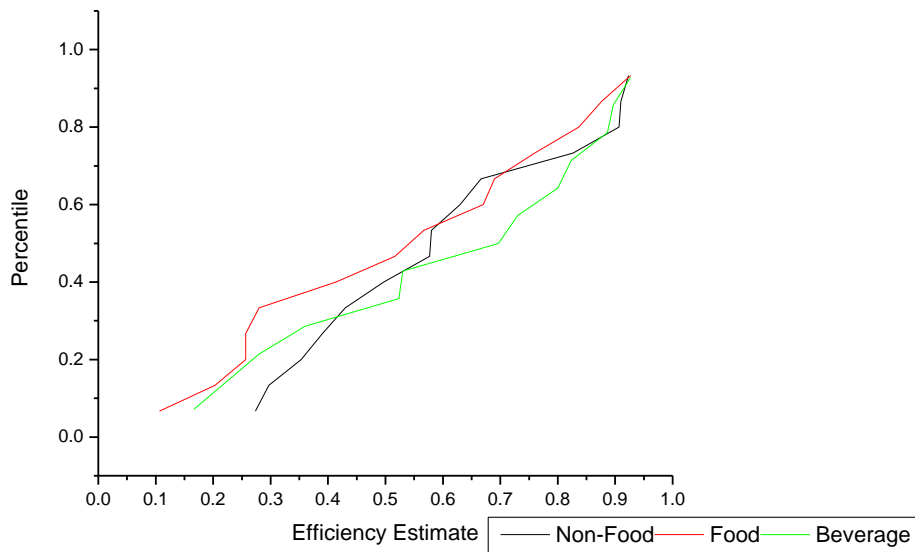
For the purposes of this study, the firms in the agro-processing industry were categorized into three groups using the nature of the output that they produce. That is the food, beverages and non-food subsectors. Table 4.8 shows the K-S test for equality of distribution of efficiency estimates, between the food and beverages, food and non-food, and beverages and non-food subsectors.

**Table 4.9: K-S test comparison percentile plot for efficiency estimates for the Food, Beverage and Non-food subsectors.**

Period	Food	Beverages	Non-food
Food			
Beverages	0.76		
Non-food	0.985	0.985	
Probability Values reported			

Source: own calculations

This result revealed no systematic difference in the distribution of efficiency estimates between the three subsectors. The study assumed that, firms in the same subsector were homogenous in nature and portrays similar characteristics. Figure 4.3 K-S test comparison percentile plots for efficiency estimates for the food, beverages and non-food subsectors were crossing each other at various points on the graph, this result also indicated that there was no significant systematic difference in the distribution of efficiency estimates among the sub sectors. This result revealed the firms in the industry were possibly facing the same factors which influence technical performance of the firms, for instance the management practices, quality of labor and raw materials could have been the same across the subsectors for period under consideration (Lundvall and Battese 2000).



**Figure 4.3: K-S test comparison percentile plot for efficiency estimates for the Food, Beverage and Non-food subsectors.**

This result indicates that policy recommendations given in this study cut across the food, beverages and non-food subsectors. This result was not directly comparable to other studies for instance Ngui and Muniu (2012) found that the distribution of efficiency estimates was different in the food, metal and textile subsectors. Figure 4.3 also indicated that on average the beverages and the non-food subsectors had relatively higher efficiency estimates than the food subsector. Table 4.1 showed that the standard deviations were larger than the means suggesting that there was a high scale of heterogeneity in the industry. This study associated the heterogeneity in table 4.2 to firm sizes and further classified the firms in the industry using their sizes. The firms were further categorized into three groups small, medium and large. The amount of value added was used for this classification. The firms with a value added less than Kenya shillings 500 million were regarded as small, firms with value added between

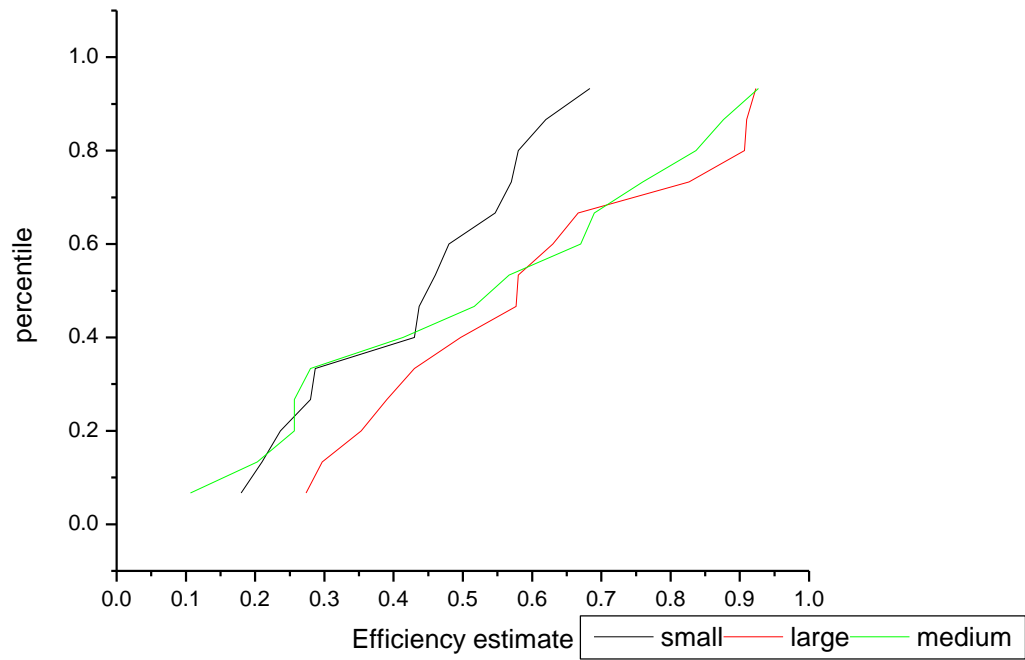
Ksh 500 million and one billion were considered as medium firms. Finally firms with value added above one billion were regarded as large firms. This classification resulted in 13 small firms, 13 medium firms and 15 large firms. Table 4.9 shows the K-S test comparison percentile plot for efficiency estimates for the small, medium and large firms' classification.

**Table 4.10: K-S test comparison percentile plot for efficiency estimates for the small, medium and large firms.**

Period	Small	Medium	Large
Small			
Medium	0.985		
Large	0.088	0.985	
Probability Values reported			

Source: own calculations

Pair wise comparison between small and medium, small and large, medium and large revealed systematic difference in the distribution of efficiency estimates between the large and the small firms. Percentile comparison plot figure 4.4 showed that the medium sized firms curved crossed the large and small sized firms at various points. From figure 4.4 this study concluded that, the larger the firms the higher the efficiency levels, this finding confirmed the prior expectation that multinational corporations in the agro-processing industry had higher efficiency estimates levels. This finding was consistent the results of Harron and Chelakumar (2012) and (Ngui and Muniu 2012).



**Figure 4.4: K-S test comparison percentile plot for efficiency estimates for the small, medium and large firms.**

## **CHAPTER FIVE**

### **SUMMARY CONCLUSIONS AND POLICY IMPLICATIONS**

#### **5.1 Introduction**

This chapter presents the summary, conclusions and policy implications of the study's findings and areas for further research.

#### **5.2 Summary**

Agro-processing is the process or action taken by manufacturers of converting primary (raw) agricultural products into consumable commodities suitable for human use. The agro processing industry consists of various subsectors including: meat processing, dairy products, fruit and vegetable processing, grain mill products, sugar mills and refineries, wine, fruit juices, beer, cocoa, chocolate and sugar confectionery, bakery products, prepared animal feeds, tea and coffee processing and packing, tobacco, essential oils and leather. This study classified all these subsectors into three major subsectors of food, beverages and non- food subsectors.

The performance of the Kenya manufacturing sector has remained below the expectations of the first Vision 2030 medium term plan and the national industrialization policy. The target growth for the manufacturing sector is 10 per cent annual growth, but instead the growth of the manufacturing sector has continued to stagnate at 3.5 per cent. The agro-processing subsector has limited value addition and processing to the fresh produce from the agricultural sector whereby Kenya is a net exporter of raw primary products and a net importer of processed products.

This study was motivated by lack of knowledge about technical efficiency in the industry. The primary objective of this study was to empirically estimate the efficiency levels of the Kenya agro-processing industry, investigate the efficiency distribution in the subsectors of food, beverage and non-food, and thereafter provide policy recommendation

This study adopted the stochastic frontier approach method to estimate the technical efficiencies of the firms and the efficiency of the industry. Random sampling was used to collect panel data covering three years (2011, 2012, and 2013) for 41 firms in the agro-processing industry. 41 firms out of a total population of 84 firms formed 50 per cent of the total population. This sample was representative of the population, and it provided a good estimate of the agro-processing industry. This data was collected from the Kenya National Bureau of Statistics (KNBS) for the said periods. The study treated labour, capital and the cost of raw materials as the input variables while the value added of the firms was the output variable.

Using Frontier 4.1 program, production frontiers were estimated for the agro-processing industry in each period. Technical efficiency of the agro-processing industry was computed from the estimated stochastic frontier model. Changes in technical efficiency were observed over time and between the beverages, food and non- food subsectors .The findings of this study were: The efficiency level for the industry was 44 per cent, and efficiency distribution was 53 per cent, 60 per cent and 57 per cent for the food, beverages, and non-food subsectors respectively for the period under consideration.

The efficiency scores for the subsectors were higher than the efficiency scores for the industry because of the asymptotic properties of the maximum likelihood estimation. That is the bigger the sample size, the higher the precision. The study findings revealed no significant difference in the distribution of efficiency estimates among the food, beverage and non- food subsectors.

### **5.3 Conclusions**

The overall technical efficiency level for the agro- processing industry was 44 per cent for the period under consideration. This result indicates a reduced efficiency performance of the Kenya agro-processing industry that on average 56 per cent technical potentialities of the agro-processing were not achieved for period 2011-2013. The efficiency distribution in the beverage, food, and non-food subsectors scored 53, 60 and 57 per cent respectively. This efficiency scores for the subsectors were higher than the efficiency score for the industry this was attributed to large sample (asymptotic) property which was not present in the subsectors. The sample size for the food, beverages, and non-food subsectors were 13, 14 and 13 respectively. A similar challenge was experienced by Ngui and Muniu (2012), Lundvall *et al.* (2002) and Sotnikov (1998). K-S test for equality of distribution of technical efficiency estimates among the subsectors revealed that, there was no significant difference in the distribution of efficiency estimates among the subsectors and across the years. Distribution of efficiency estimates was found to be different significantly on basis of firm size. The larger the firms the higher the efficiency industry for period under consideration needs to be improved so that this industry can reach a maximum

production. Test for equality of distribution revealed that there was no systematic difference in the distribution of efficiency estimates among the subsectors and across the years. This result revealed that the firms in the industry were possibly facing the same factors which influence technical performance of the firms for instance the management practices, quality of labour and raw materials could have been the same across the subsectors for period under consideration (Lundvall and Battese, 2000). This result indicates that policy recommendations given in this study cut across the food, beverages and non-food subsectors.

#### **5.4 Policy implications**

The agro-processing industry did not achieve 56 percent potentiality in the year 2011-2013. This study recommended that the technical potentiality of the firms in the agro-processing industry be improved to make sure the investors in this industry get maximum returns from their investments. In light of the study findings, the following recommendations are made:

The results of this study revealed that the overall technical efficiency for the agro-processing industry was below average for the period under consideration. This study recommends that export promotion of locally processed products policy of the Kenyan government should be complemented with an industrial policy that enhances the technical efficiency of local exporting firms to increase international competition of Kenyan manufacturers. For instance, the government should ensure competitive pricing of inputs by not only investing heavily in human resource development, but also

adopting selective and targeted strategies for foreign direct investments and local investments. This would ensure that firms do not experience restrained access to inputs. The negative relationship between firm size and efficiency for the agro-processing industry for the period 2011-2013, could be partly explained by operation of excessively large firms driven by increases in factor inputs rather than improvements in productivity, hence leading to higher complexity in larger firms that makes identification of inefficiency more difficult than in smaller firms. Hence, support programmes should not only be geared towards stimulating the growth in size rather than number of firms, but also improving the technical efficiency and consequently the total factor productivity of the firms. In addition to this foreign direct investments are considered as a credible source of innovations. This study recommends that small firms should improve their product innovations, marketing innovations and process innovations by taking advantage of the spillover effects from the multinational corporations in the agro-processing industry, since the results of this study indicated that large firms had high efficiency estimates than small firms in the industry for the period under consideration.

The raw materials for the agro-processing industry comes from the agricultural sector, this implies that technical efficiency improvement of the agro-processing industry can help to leverage the success of the agricultural sector. This study therefore, recommends that the government strengthens the agricultural sector. For instance, the agricultural sector can be strengthened through coming up with innovative farming techniques, for example biotechnology, coming up with more irrigation schemes to make sure that the

agricultural sector remains productive even in the dry seasons. The government should also provide incentives to the small and medium enterprises willing to invest in the agro processing industry by providing subsidized electricity and fuel for industrial production.

### **5.5 Limitations and areas of further research**

Data on inputs and outputs of the firms is confidential and was not easy to collect and this a major challenge of panel manufacturing data. Most manufacturing firms especially the small and medium sized firms do not publish their financial statements especially on the value added; this was attributed to fear of the taxation authorities and fear of competitions from other firms in the industry. These challenges could have been addressed only by collecting primary data from the firms, and this was not possible due to time and financial resource constraints. The areas for further research include one, estimating efficiency of privately owned agro-processing firms. Two, estimating the efficiency of public agro processing firms and parastatal. Three, comparing the performance of publicly and privately agro-processing firms and fourth, extending the current study to investigate the factors that explain efficiency levels differences of the agro-processing firms.

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### Appendix A1: Maximum likelihood estimation of the translog production

The OLS estimates :			
Value added	Coefficient	standard-error	t- ratio
Constant	0.3482	0.1177	2.958
Raw materials	-0.1935	0.1554	-1.244
cost of labour***	0.1087	0.1053	1.031
capital	0.2257	0.516	0.4373
Raw materials x Raw materials	0.2051	0.3537	0.5797
Labour x labour	0.1412	0.4394	0.3212
Capital x capital	-0.6039	0.6407	-0.943
Raw materials x Labour	-0.1467	0.7245	0.2024
Raw Materils x capital	-0.2012	0.4517	0.4455
Labour x capital	-0.4838	0.3496	-1.384
sigma-squared	0.9045		
log likelihood function = -0.16259538			
The final MLE estimates are :			
Value added	Coefficien t	standard - error	t- ratio
Constant	0.2687	0.8278	0.3246
Raw materials	0.1201	0.1222	0.9823
cost of labour	-0.1	0.1332	-0.751
capital***	0.5952	0.3137	1.897
Raw materials x Raw materials***	0.9253	0.3742	2.472
Labour x labour	0.2437	0.6153	0.396
Capital x capital	-0.1048	0.56	-0.187
Raw materials x Labour	-0.2377	0.6631	-0.359
Raw Materils x capital	-0.2017	0.5714	-0.353
Labour x capital***	0.4909	0.1905	2.577
sigma-squared	0.1244	0.4884	0.2548
gamma***	0.9583	0.1559	6.147
log likelihood function = -0.78619935			

Note \*\*\* indicates statistically significant parameters at 5% significance level

## Appendix A2: Kodde and Palm critical Values

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TABLE I  
UPPER AND LOWER BOUNDS FOR THE CRITICAL VALUE FOR JOINTLY TESTING EQUALITY  
AND INEQUALITY RESTRICTIONS<sup>a</sup>

df	$\alpha$ .25	.10	.05	.025	.01	.005	.001
1	0.455	1.642	2.706	3.841	5.412	6.635	9.500
2	2.090	3.808	5.138	6.483	8.273	9.634	12.810
3	3.475	5.528	7.045	8.542	10.501	11.971	15.357
4	4.776	7.094	8.761	10.384	12.483	14.045	17.612
5	6.031	8.574	10.371	12.103	14.325	15.968	19.696
6	7.257	9.998	11.911	13.742	16.074	17.791	21.666
7	8.461	11.383	13.401	15.321	17.755	19.540	23.551
8	9.648	12.737	14.853	16.856	19.384	21.232	25.370
9	10.823	14.067	16.274	18.354	20.972	22.879	27.133
10	11.987	15.377	17.670	19.824	22.525	24.488	28.856
11	13.142	16.670	19.045	21.268	24.049	26.065	30.542
12	14.289	17.949	20.410	22.691	25.549	27.616	32.196
13	15.430	19.216	21.742	24.096	27.026	29.143	33.823
14	16.566	20.472	23.069	25.484	28.485	30.649	35.425
15	17.696	21.718	24.384	26.856	29.927	32.136	37.005
16	18.824	22.956	25.689	28.219	31.353	33.607	38.566
17	19.943	24.186	26.983	29.569	32.766	35.063	40.109
18	21.060	25.409	28.268	30.908	34.167	36.505	41.636
19	22.174	26.625	29.545	32.237	35.556	37.935	43.148
20	23.285	27.835	30.814	33.557	36.935	39.353	44.646
21	24.394	29.040	32.077	34.869	38.304	40.761	46.133
22	25.499	30.240	33.333	36.173	39.664	42.158	47.607
23	26.602	31.436	34.583	37.470	41.016	43.547	49.071
24	27.703	32.627	35.827	38.761	42.360	44.927	50.524
25	28.801	33.813	37.066	40.045	43.696	46.299	51.986

## Appendix A3: Test for fixed effects

. testparm x11 x21 x31 year

( 1) x11 = 0  
( 2) x21 = 0  
( 3) x31 = 0

F( 3, 79) = 0.30  
Prob > F = 0.8233

## Appendix A4: Test for Random effects

. **xttest0**

Breusch and Pagan Lagrangian multiplier test for random effects

$$y1[\text{firm1},t] = x_b + u[\text{firm1}] + e[\text{firm1},t]$$

Estimated results:

	var	sd = sqrt(var)
y1	<b>1271</b>	<b>35.65109</b>
e	<b>284.4929</b>	<b>16.86692</b>
u	<b>657.466</b>	<b>25.6411</b>

Test: Var(u) = 0

chi2(1) = **46.64**  
Prob > chi2 = **0.0000**

.

## Appendix A5: Data used in efficiency estimation

		YEAR	Net sales (Y)	raw materials (X1)	Staff expenses (X2)	Plant machinery (X3)
1	Manufacture of tea	11	808,168,316	594,754,286	6,920,075	261,113,893
		12	753,489,352	583,300,112	6,691,330	319,731,960
		13	948,951,888	733,667,663	7,791,955	362,679,006
2	Manufacture of tea	11	926,059,913	702,825,513	8,705,343	206,955,815
		12	942,400,692	722,646,060	9,954,473	268,410,195
		13	1,120,037,048	851,411,475	8,686,154	344,126,302
3	Manufacture of tea	11	1,135,227,011	954,935,484	9,174,078	291,939,925
		12	1,198,237,937	973,111,672	11,039,287	390,068,258
		13	1,504,258,738	1,169,803,950	11,708,062	418,510,150
4	Manufacture of tea	11	958,320,604	698,386,688	11,481,831	607,946,200
		12	992,228,657	746,773,786	14,709,658	694,727,093
		13	1,171,401,442	897,514,972	13,953,278	691,286,102
5	Manufacture of tea	11	1,385,242,996	1,039,292,883	12,172,579	885,953,748
		12	1,375,875,013	1,045,408,476	12,923,707	887,223,750
		13	1,719,557,832	1,209,755,074	16,185,756	829,086,051
6	Manufacture of tea and coffee	11	2,305,657,000	407,781,000	153,515,000	2,402,791,000
		12	2,446,304,000	394,372,000	169,938,000	3,037,442,000
		13	2,494,222,000	492,687,000	191,271,000	3,173,824,000
7	Manufacture of coffee	11	1,560,149,000	781,674,000	420,519,000	630,427,000
		12	1,564,792,000	394,455,000	407,591,000	552,635,000
		13	1,384,375,000	461,759,000	361,999,000	544,697,000
8	Manufacture of coffee	11	143,219,000	5,213,000	12,023,000	305,146,000
		12	157,075,000	6,877,000	12,786,000	307,723,000
		13	68,025,000	8,759,000	12,982,000	303,328,000
9	Processing of sugar	11	15,795,300,000	126,934,000	1,986,873,000	156,732,000
		12	15,542,686,000	396,136,000	1,997,849,000	206,603,000
		13	11,156,123,000	380,387,000	2,117,458,000	315,676,000

## Appendix A5: Data used in efficiency estimation

10	Processing of sugar	11	3,961,290,943	290,176,254	16,339,503	5,942,413,034
		12	5,286,654,329	443,896,298	19,377,644	6,240,748,738
		13	5,827,546,238	513,726,113	19,893,116	5,513,213,005
11	Manufacture of beer	11	38,862,508,000	1,929,234,000	5,039,632,000	28,304,026,000
		12	44,784,207,000	1,969,028,000	5,759,300,000	31,246,602,000
		13	49,880,429,000	2,996,750,000	6,522,748,000	33,715,088,000
12	Processing of daily products	11	10,040,350,392	5,733,181,421	4,931,273,109	3,799,862,958
		12	12,550,437,990	8,243,269,019	7,441,360,707	6,309,950,556
		13	15,688,047,488	11,380,878,516	10,578,970,205	9,447,560,054
13	Processing of daily products	11	457,283,645	350,622,112	180,968,404	275,714,955
		12	571,604,557	464,943,024	295,289,316	390,035,867
		13	714,505,696	607,844,163	438,190,455	532,937,006
14	Processing of vegetables and oils	11	5,173,000,000	882,000,000	625,000,000	1,121,000,000
		12	5,327,000,000	887,000,000	629,000,000	1,123,000,000
		13	5,535,000,000	890,000,000	631,000,000	1,127,000,000
15	Processing of fruits	11	26,894,182,000	149,036,000	297,550,000	23,506,475
		12	29,684,494,000	129,482,000	271,934,000	22,441,555
		13	47,090,526,000	112,650,000	302,381,000	21,514,697
16	Manufacture of grain mill	11	8,233,373,000	1,281,844,000	463,319,000	1,496,184,000
		12	9,746,029,000	1,672,951,000	559,447,000	1,633,333,000
		13	9,554,392,000	2,512,800,000	554,995,000	2,209,074,000
17	Processing and preservation of meat	11	577,073,563	961,568,227	133,727,587	1,136,925,563
		12	574,765,269	956,960,872	129,120,232	1,134,617,269
		13	572,466,208	959,259,933	131,419,293	1,132,318,208
18	Processing and preservation of meat	11	2,085,662,023	856,217,548	40,626,454	83,806,297
		12	2,077,319,375	864,526,825	48,935,731	75,463,649
		13	2,069,010,098	872,869,473	57,278,379	67,154,372

## Appendix A5: Data used in efficiency estimation

19	Manufacture of grain mill	11	15,207,038	10,617,949	6,209,580	3,236,280
		12	16,362,773	11,773,684	7,365,315	4,392,015
		13	17,606,344	13,017,255	8,608,886	5,635,586
20	Manufacture of grain mill	11	341,964,349	223,321,214	148,188,222	207,301,214
		12	367,953,640	249,310,505	174,177,513	261,254,981
		13	395,918,116	277,274,981	202,141,989	233,290,505
21	Manufacture of grain mill	11	2,115,083,086	1,781,033,086	313,961,086	394,283,086
		12	2,275,829,400	1,941,779,400	474,707,400	555,029,400
		13	2,448,792,435	2,114,742,435	647,670,435	727,992,435

22	Manufacture of bakery products	11	40,890,494	23,641,007	5,069,131	7,806,547
		12	42,444,333	25,194,846	6,622,970	9,360,386
		13	44,057,218	26,807,731	8,235,855	10,973,271
24	manufacture of bakery products	11	1,588,981,836	1,031,400,126	534,052,914	191,545,956
		12	1,649,363,146	1,091,781,436	594,434,224	251,927,266
		13	1,712,038,945	1,154,457,235	657,110,023	314,603,065
25	Manufacture of cocoa, sugar and chocolate confectionaries	11	1,641,824,745	518,791,553	175,857,656	218,472,016
		12	1,577,793,580	582,822,718	239,888,821	282,503,181
		13	1,516,259,631	521,288,768	178,354,871	220,969,231
26	Manufacture of cocoa, sugar and chocolate confectionaries	11	1,923,490,625	378,087,940	295,153,788	464,344,241
		12	1,998,506,759	75,016,134	370,169,922	539,360,375
		13	2,076,448,523	152,957,898	448,111,686	617,302,139
27	Manufacture of cocoa, sugar and chocolate confectionaries	11	832,610,409	336,332,769	82,013,761	101,126,356
		12	898,820,422	368,804,575	114,485,567	167,336,369
		13	865,082,215	402,542,782	148,223,774	133,598,162

## Appendix A5: Data used in efficiency estimation

28	Manufacture of Tobacco	11	19,667,003,000	299,000,000	3,776,000,000	6,756,340,000
		12	19,409,000,000	427,000,000	3,131,000,000	6,426,112,220
		13	19,619,000,000	253,000,000	3,207,000,000	6,178,965,489
29	Processing of seeds	11	11,941,200,000	2,148,300,000	559,800,000	2,722,500,000
		12	12,781,800,000	2,176,200,000	686,700,000	2,873,700,000
		13	13,219,200,000	2,154,600,000	600,300,000	3,155,400,000
30	Processing of sisal	11	1,907,632,000	302,864,000	596,549,000	753,404,000
		12	2,268,583,000	225,811,000	699,104,000	806,444,000
		13	2,311,247,000	199,072,000	759,502,000	833,764,000
31	Processing of hides and skin	11	5,711,060,700	412,349,409	13,116,463	658,684,253
		12	6,390,094,500	390,024,408	13,850,857	792,293,519
		13	6,782,530,500	372,692,076	18,422,188	839,290,144
32	Manufacture of seeds	11	29,158,650,000	18,380,250,000	3,215,700,000	2,069,550,000
		12	31,064,850,000	20,430,900,000	3,487,050,000	2,455,650,000
		13	31,679,100,000	19,867,950,000	3,547,800,000	3,388,500,000
33	Manufacture of seeds	11	51,417,090	1,523,620,080	25,992,990	3,599,787,240
		12	141,547,770	719,299,890	41,232,060	3,830,876,280
		13	800,010,000	721,110,330	41,722,020	4,110,497,460
34	Manufacture of foot wear	11	271,076,770	163,105,932	22,732,451	30,539,476
		12	271,890,000	163,919,162	23,545,681	31,352,706
		13	272,705,670	164,734,832	24,361,351	32,168,376
35	Manufacture of foot wear	11	658,935,895	191,355,895	7,324,263	110,035,895
		12	660,912,703	193,332,703	9,301,071	112,012,703
		13	662,895,441	195,315,441	11,283,809	113,995,441
36	Weaving of textiles	11	278,905,928	144,005,928	77,005,928	173,215,176
		12	316,342,076	162,134,813	95,134,813	210,651,324
		13	297,034,813	181,442,076	114,442,076	191,344,061

## Appendix A5: Data used in efficiency estimation

37	Weaving of textiles	11	100,769,627	237,810,066	103,870,098	176,225,216
		12	107,319,653	244,360,092	110,420,124	182,775,242
		13	114,295,430	6,975,777	117,395,901	189,751,019
38	Preparation and spinning of textile fibres	11	116,660,054	365,621,335	24,939,103	25,666,006
		12	119,576,556	368,537,837	27,855,605	31,571,921
		13	122,565,969	371,527,250	30,845,018	28,582,508
39	Manufacture of prepared animal feeds	11	4,729,524,228	3,446,020,006	730,393,205	875,274,209
		12	5,136,263,311	3,852,759,089	1,137,132,288	1,282,013,292
		13	5,577,981,956	4,294,477,734	1,578,850,933	1,723,731,937
40	Manufacture of prepared animal feeds	11	164,338,871	136,069,017	30,406,137	26,604,499
		12	178,472,014	150,202,160	44,539,280	56,086,236
		13	193,820,608	165,550,754	59,887,874	40,737,642
41	Manufacture of prepared animal feeds	11	471,677,305	398,636,518	82,245,921	143,929,957
		12	512,241,553	439,200,766	122,810,169	184,494,205
		13	556,294,326	483,253,539	166,862,942	228,546,978