# TECHNICAL EFFICIENCY OF MANUFACTURING FIRMS IN KENYA

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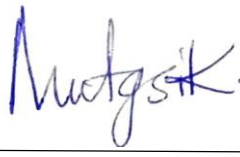
# DECLARATION

This research project is my original work and has not been presented to any University for any award.



**September 20th, 2022**

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This research project has been submitted for examination with my approval as the University Supervisor.

**September 21st, 2022**

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## DEDICATION

To my late kid brother Emmanuel Baraka Abere, who meant so much to me.

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| | |
|---|---|
| ERSWEC | Economic Recovery Strategy for Wealth and Employment Creation |
| GDP | Gross Domestic Product |
| KIPPRA | Kenya Institute for Public Policy Research and Analysis |
| MITC | Ministry of Industrial Transformation, Trade and Cooperatives |
| MTP III | Third Medium Term Plan |
| R&D | Research and Development |
| SDGs | Sustainable Development Goals |
| SFA | Stochastic Frontier Analysis |
| SME | Small and Medium sized Enterprises |

# ABSTRACT

Manufacturing is critical to any country's economic development, and Kenya is no exception. The direct and indirect externalities from manufacturing range from increased industrialization, job creation, multiplier effect, and direct contribution to a country's Gross Domestic Product. The primary goal of this research is to identify the factors that influence the technical efficiency of Kenyan manufacturing firms. The specific objectives are as follows: to determine the level of technical efficiency of Kenyan manufacturing firms and to identify the factors that influence the technical efficiency of Kenyan manufacturing firms. This research is informed by the firm theory, production theory, and efficiency theory. The World Bank Enterprise Survey Data for the year 2018 was used in this study because it is the most recent data available for manufacturing firms in Kenya. This data reports on various indicators of technical efficiency for individual firms and industries, as well as information on the qualitative and quantitative characteristics of these manufacturing firms. The variables that have been focused on in this study include the age and size of the firm, the managerial experience of the top executive, the structure of ownership, the exporting status of the firm, the location of the firm, the industry the firm is in, and finally, whether or not the firm undertakes research and development activities. In this study, the parametric Stochastic Frontier Analysis approach was used to assess efficiency. It is preferred to other methods like Data Envelopment Analysis (DEA) because when compared to DEA, SFA is better as it accounts for the noise, or random effects and is also able to provide a structure to figure out the causes of inefficiency in production and the causes of varying levels of productivity which are of great use while making conclusions of how inefficiency can be reduced and productivity increased. The model estimated that the technical efficiency of Kenyan manufacturing firms is 42.54%, implying that Kenyan manufacturing firms operate at a level 57.46% lower than their optimal level of operation. The study has finally analyzed the factors that influence this level of technical efficiency and has given recommendations on how the government can address these factors.

# CHAPTER ONE
# INTRODUCTION

## 1.1 Study Background

Development literature from the past emphasized the importance of the manufacturing industry in driving economic development (Chakravarty & Mitra, 2009), (Szirmai & Verspagen, 2015), (Haraguchi et al., 2017). (Attiah, 2019) States that as the share of manufacturing in the GDP of a developing country increases, so does the economic development increase through increased industrialization.

Not only does manufacturing bring about industrialization, but it also brings about structural change which refers to when resources move from areas where productivity is low into areas where productivity is high. (Tybout, 2000) Emphasizes how important the manufacturing sector is in enabling industrialization in developing countries. This is because it can drive economic growth by increasing employment opportunities, reducing poverty, and shifting the focus of a country's exports from low-value goods to goods that are of a higher value due to the value addition done through manufacturing. The enhancement of value addition processes through manufacturing also opens up new market opportunities and thus increasing household incomes within the economy.

As a sector, it provides opportunities for capital accumulation and economies of scale, which are less available in the services sector and agricultural sectors (Attiah, 2019). This, therefore, means that, by increasing the share of the manufacturing sector output value in the GDP, economic growth will increase in developing countries. Also, the linkages and spillover effects caused by the manufacturing sector cause more positive externalities in investments in other sectors and subsectors of the economy.

Manufacturing is considered a key economic driver to transforming productivity to higher levels (Page, 2010). He argues that industrialization brings about structural change without which, African countries cannot be able to sustain growth. The structural change brought about by manufacturing growth aside from all the benefits discussed earlier will enable a country to increase resilience against economic shocks and thus, it will be able to offer a cushion for the poor in the case of countries in Sub-Saharan Africa (Balchin N., Gelb S., Kennan J., Martin H., Williams C., 2016).

According to (Imbs & Wacziarg, 2003) as a country diversifies its manufacturing production, per capita income increases. The diversification will cause an increase in the production of new products, increasing the market size reached by a country. As these goods enter the international market, gradually they become more competitive while increasing foreign exchange earnings in the process. As time progresses, the country will identify with which products it has a competitive advantage and thus begin specialization. Therefore, the relationship between specialization and per capita income is U shaped (Tybout, 2000).

In most African countries, in the periods after independence, the leaders who were put in place saw industrialization especially the manufacturing of import substitutes, as the only way for them to develop their economies (Mwenzwa & Misati, 2014). This idea was not well thought out in many countries and thus it led to unsustainable and uncompetitive industries. From the 1960s to the 1990s, manufacturing and industrialization in general in these countries reduced and after that, it has stagnated in some countries and continued to decline in others (Mwenzwa & Misati, 2014). In the case of Sub-Saharan Africa, even though the percentage of manufacturing in the GDP fell from 18% in 1975 to 11% in 2014, the amount of production from manufacturing has more than doubled, and the number of people employed to work in these industries has also increased considerably (Balchin et al., 2016). This is in contrast to the understanding of some that Africa has deindustrialized, while actually, it all depends on the data that one looks at. (J. Page, 2010) Says that for African countries to reduce their vulnerability to shocks and prevent a constant decline in prices, they will have to embrace industrialization and also experience a structural change in the process.

There are, however, major challenges in the industrial sectors in African countries which cause them to have low levels of industrialization and structural change and thus negatively affect economic development. Some of the challenges being faced by the manufacturing sector in developing economies majorly in Africa include infrastructural inadequacies, volatile macroeconomic environments, political instabilities, low level of investments in research and development among the firms, and a lack of skilled labour (Tybout, 2000). Other challenges as studied by (J. Page, 2012) include, limited participation in task-based production, a lack of a proper understanding of industrial agglomeration to enable favorable policies to be formed, and the abilities of firms in Africa to obtain capabilities from global industries and master them so that they can stand a chance to compete with them.

(Coelli et al., 2005) Says that the degree of productivity of a firm is what can be put in place to gauge the performance of the firm. Specifically, how the firm allocates its resources effectively to have optimal value addition. The concept of efficiency can be described as a state in which all the resources that are put into production are allocated optimally in a way that minimizes waste and inefficiency. In economics, production efficiency can be presented in two ways, that is, allocative efficiency and technical efficiency. Economic efficiency is when a society has both allocative and technical efficiencies. Here, I focus on technical efficiency which refers to a situation where a firm produces the maximum amount of output possible, given the amount of input or resources the firm has. The basic formula to calculate, $\text{Technical Efficiency} = \frac{\text{Actual output of a firm}}{\text{Maximum possible output}}$. Here, however, I am looking at efficiency on a deeper level and using the stochastic frontier analysis to analyze the technical efficiency of Kenyan manufacturing firms.

There are numerous factors that influence the technical efficiency of manufacturing firms in general. (Faruq & Yi, 2010) Explain how these various determinants affect the technical efficiency of Ghanaian manufacturing firms. They consider factors such as the firm's size and age, the amount of labor and capital available in the firm, and whether the firm is owned by Ghanaians or foreigners. These factors serve as a guideline for what to consider when calculating the technical efficiency of Kenyan manufacturing firms. However, I am including various industries within Kenyan manufacturing, such as chemicals and pharmaceuticals, electronics, food, textiles and garments, and metals and machinery. I also include the location of the industries and concentrate mainly on those in Nairobi, Mombasa, Kiambu, and Nakuru to find out the relation that firm location has with its efficiency. (Singh et al., 2019) Propose several factors, such as increasing firms' investments in R&D, increasing their collaboration with academic institutions and scientists to broaden their knowledge of technology trends, and increasing the technical efficiencies of Indian manufacturing firms.

### 1.2 Manufacturing in Kenya

Manufacturing is a priority area for the implementation of the Sustainable Development Goals (SDGs) in Kenya, as it is in other African countries. Not only is it a priority with regard to the Sustainable Development Goals, but it is also a priority according to the two economic development blueprints for the country. The first economic development blueprint is the Kenya

Vision 2030, which succeeded the Economic Recovery Strategy for Wealth and Employment Creation (ERSWEC) that was there from 2003 to 2007 (Mwenzwa & Misati, 2014). It took effect in 2008 and it shows the roadmap that the country is set to take to be an economically developed nation by 2030. This means that it aims to elevate Kenya to the status of a middle-income country, which will not only improve citizens' livelihoods but also Kenya's competitiveness and global prosperity. It contains three pillars, the political pillar, the social pillar, and the economic pillar. Manufacturing falls under the economic pillar.

The second blueprint is the Jubilee Government's Big Four agenda, which is part of the Vision 2030's Third Medium-Term Plan (MTP III), which runs from 2018 to 2022. Here, four key focus areas need to be achieved. They include affordable housing, universal healthcare, food security, and last but not least, manufacturing and job creation.

### 1.2.1 Performance of Manufacturing Sector in Kenya

As seen above, manufacturing is a very important sector in spearheading Kenya’s development, given that a majority of the development blueprints include the sector in their plans. Despite its importance, however, (Were, 2016) explains that even as the GDP of the country keeps on increasing, the share of manufacturing in the GDP keeps on reducing and thus showing signs that Kenya is undergoing a period of premature deindustrialization.

The Kenya Institute for Public Policy Research and Analysis (KIPPRA) in their 2020 annual report, found from their data that about seven counties within the country participate substantially in manufacturing. They also found out that these counties bring in significantly more revenue compared to those whose main undertakings are agricultural. They thus encourage more counties to pursue structural transformation by creating environments that attract manufacturing investments. Also, only about 15% of the counties in Kenya undertake manufacturing activities. The report shows that the counties with high manufacturing activities like Nairobi and Nakuru attract more population due to the ability of this sector to generate employment. Thus explaining the high populations in these counties.

KIPPRA Also stated that Manufacturing, together with agriculture and wholesale, and retail are the three sectors that have the potential to improve the economic growth within counties, and thus it is wise to have more budget allocated to them to enhance this process. According to the report, the manufacturing sector contributed 18.5% of GDP in 2010, but only 16.2% in 2019. The reason

for this was thought to be competition from other imported goods, the sugar industry's poor performance, and rising production costs.

### 1.2.2 Kenya's Manufacturing Sector Challenges

According to (Were, 2016), several challenges face the manufacturing sector in Kenya, which include the following, inadequate infrastructure, poor level of capabilities and skills in the sectors that are important within manufacturing, poor quality of inputs, high costs of running the operations of firms, low market access which hinder high production and lastly, policies that are unfavorable to investors who end up investing in other countries. These are the factors specific to the Kenyan manufacturing and industrial sector.

There are however other challenges that are not as straightforward, for example, the discord within the Ministry of Industrial Transformation, Trade and Cooperatives (MITC), which causes an overlap of strategies and policies leading to confusion and poor results being delivered by the implementation of them (Were, 2016). According to the Vision 2030 development blueprint, the manufacturing industries that were identified to have the potential to salvage Kenya from deindustrialization were the steel and iron industries. However, the MITC while developing policies and strategies, led the manufacturing sector to focus on leather and textile development and the agro-industry.

Devolution has also had both negative and positive effects on the manufacturing sector. But more negatives than positives. For instance, by scaling down the government processes to 47 counties, investments in manufacturing have become expensive due to the increase in costs. This is discouraging to investors. The counties also try to find ways in which to increase their revenue and end up increasing licenses and fees which affect the already existing manufacturers negatively as well.

## 1.3 Statement of the problem

Comparing Kenya to other countries in Africa, Kenya is third in the production of food and beverages, as well as in the production of textiles, clothing, leather, and footwear, and is first in the manufacturing of chemicals. Overall, Nigeria is the leader when it comes to the growth of value in manufacturing exports (Were, 2016). In East Africa, Kenya is leading in terms of the value of manufacturing exports that it produces, but manufacturing in other countries like Rwanda,

Tanzania, and Uganda has a higher growth rate than that of Kenya (Were, 2016). Therefore, if the trend continues, it is likely that Kenya will be overtaken by these other countries and lose its position.

Kenya's development blueprints, Vision 2030, the Big Four agenda, and the Kenyan constitution all place an emphasis on the manufacturing sector. They highlight its importance in structural change which is needed to propel the country towards economic development. We cannot make any meaningful industrial development without first understanding the technical efficiency issues that manufacturing firms in Kenya face. Also, with the statistics, we have seen and the trend of deindustrialization in Kenya, it seems fit to conduct a study of the technical efficiency of manufacturing institutions in Kenya, which will enable policymakers to find the root cause of inefficiencies in the firms in these sectors and have policy suggestions which provide direction on improving this sector.

### 1.4 Research questions

The study was set up in a way that answers one main question which is; what are the determinants of technical efficiency of the manufacturing firms in Kenya? Aside from this, there are:

I. What factors influence the technical efficiency of Kenyan manufacturing firms?
II. What is the level of technical efficiency of the manufacturing firms in Kenya?

Which are the more specific questions that the study sought to answer.

### 1.5 Research Objectives

The study had one main objective which is to find out the factors that determine the technical efficiency of manufacturing firms in Kenya.

The specific objectives are as follows:

I. To determine the level of technical efficiency of manufacturing firms in Kenya
II. To establish the factors that influence the technical efficiency of manufacturing firms in Kenya.

### 1.6 Significance of the study

The importance of this study is highlighted by the great emphasis on it by Kenya's development plans. The expectations set for it by Vision 2030, the Big Four agenda, and the Kenyan constitution

must be met in order for us to achieve middle-income status. The study allowed us to delve deeper into the factors that influence efficiency in this critical sector of the Kenyan economy and identify the areas that cause inefficiency in this sector. In finding out the inefficiencies and working on them at the county level, the structural change and diversification caused will propel the whole country towards economic development.

The study was also important as previous literature was done on the topic focused on manufacturing in its entirety and did not focus on the firms, and others also used data from the World Bank that was outdated. This study looked at recent data from the World Bank's Enterprise Survey Data in 2018 to calculate the efficiency of manufacturing firms in Kenya as well as the sources of their inefficiencies.

## 1.7 Organization of the Study

The following sections after this were arranged such that, chapter two looked at the literature that has been reviewed to inform the process of this study, chapter three has the methodology that was used to assess the research questions, chapters four and five have the analysis of data and conclusions of the study together with policy recommendations respectively.

# CHAPTER TWO
# LITERATURE REVIEW

## 2.0 Introduction

In this section, I looked at previous literature that has been studied to inform this study. It begins with the theoretical review of literature which looks at the theories already in place concerning technical efficiency and what determines it in production and manufacturing. The next part is the empirical literature review which took a look into the different factors that determined technical efficiency in the work of other scholars.

## 2.1 Theoretical Literature Review

(Tingum, 2014) States that there are other ways to analyze whether manufacturing firms are doing well or not for example, through assessing how profitable they are by measuring their return on assets, by analyzing their profit margins, or by assessing the firm's total assets turnover. These methods are all right, but do contain inherent problems since they fail to include the effects of a firm's environment on its operations. Efficiency is able to cater to these effects and thus solve this problem, by showing how efficient a firm is.

The economic theories of the past, the neoclassical economic theories of production, assumed that the production process is always efficient (Kokkinou, 2010) and that firms always produced the maximum possible output during production. This can be seen in the theory of production, whose basic equation assumes that an input unit can be used to produce only one unit of output, which is the maximum possible output, and thus there is no inefficiency.

This, however, is not the case in the real world, since the production process is not always linear and efficient and thus may have some inefficiency. The econometricians during this period used to estimate the average production functions until (Farrell, 1957) introduced the notion of frontier production functions, intending to connect empirical work and theory(Aigner et al., 1977).

The cause of this inefficiency was due to exogenous factors affecting the firm that the producers had no control over, as well as due to inefficiencies within the firm (Kokkinou, 2010). In this study, we looked at the factors affecting the technical efficiency of Kenyan manufacturing firms as well as the degree of this inefficiency.

According to (Farrell, 1957), a firm's economic efficiency refers to a state whereby a firm has all its resources allocated optimally to serve the firm in the best way possible while reducing inefficiencies. It has two components; technical and allocative efficiencies. Technical efficiency has been defined by (Barasa et al., 2018) as a concept that is associated with output maximization, given a specific combination of inputs. Allocative efficiency is described by (Coelli et al., 2005) as a firm's ability to put its inputs to use in the best possible combination given their prices in order to optimize the production cost. It can be said, that allocative efficiency aims at maximizing profits. Technical and allocative efficiency measures, together give the measure of total economic efficiency. Inefficiency, therefore, is referred to as the difference between the maximum achievable output from a given input combination and the amount of output observed (Barasa et al., 2018).

In this study, we look at technical efficiency. Technical efficiency can be determined by two methods, the first one being the input orientation measure and the second one being the output orientation measure. The input orientation is explained below, according to (Farrell, 1957a). With regard to the measure of output orientation, (Tipi et al., 2009) takes it that there is a single input unit that is being used to produce multiple amounts of output.

In microeconomics, technical efficiency can be explained by the production possibility frontier, as shown by (Farrell, 1957), in figure 2.1 below. The figure is to be associated with the input orientation method of determining the technical efficiency of a firm, a method that supposes that a firm uses a certain input combination to produce a given fixed amount of output.

**Figure 2.1.0: Input Oriented Measure of Technical Efficiency.**

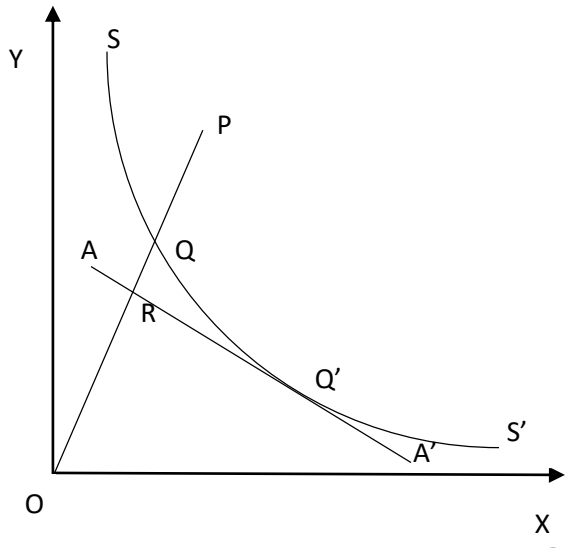
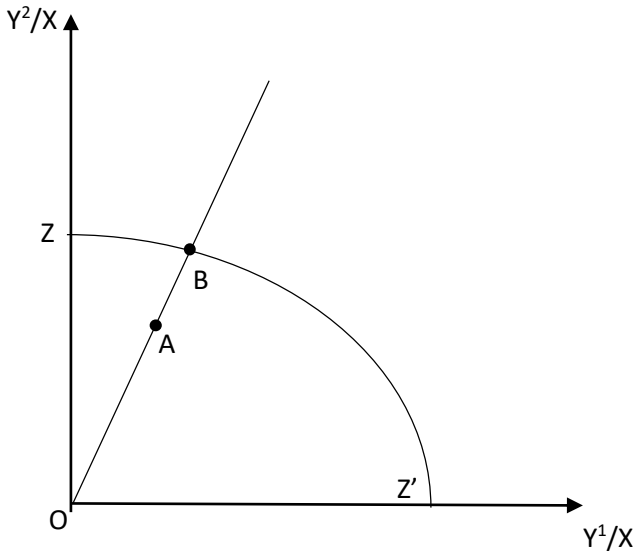


Figure 2.1 can be used to explain the input-oriented approach with a firm whose aim is to produce the optimal level of output. In this diagram, (Farrell, 1957a) takes it that there are only two inputs in the production process, which he refers to as factors. SS' is the isoquant that shows the various combinations of the two factors that have to be used in producing the given fixed amount of output, for a technically efficient firm. The point P represents a firm that is being observed and the combination of inputs that the firm is using to produce the fixed amount of output. At this point, the firm is technically inefficient. At point Q, a firm is producing the same amount of output as P and is technically efficient. If the firm at P was to operate at point Q, it would be using a fraction of the inputs it is using. The line OP can therefore be used to illustrate the degree of technical inefficiency in that, along this line, a firm can determine by how much they can reduce their inputs while maintaining a certain optimal level of output. The firm at point P thus has to reduce its inputs by the ratio $\frac{\mathrm{QP}}{\mathrm{OP}}$ for it to experience technical efficiency. Technical efficiency can therefore be measured as follows: $1 - \frac{QP}{OP}\ or = \frac{OQ}{OP}$.

Thus, $\frac{\mathrm{OQ}}{\mathrm{OP}}$ can be equated to technical efficiency.

**Figure 2.2.0: Output Oriented Measure of Technical Efficiency**




The output oriented measure of technical efficiency shows the different quantities of outputs that can be produced given a fixed amount of inputs. To illustrate this, (Farrell, 1957) illustrated that the efficiency of a firm is to be measured with respect to an efficient production frontier. The

production frontier represents a given amount of output that any efficient firm can produce, from different input combinations. The curve ZZ' is our Production Possibility Curve (PPC). The two outputs being produced are $Y^1$ and $Y^2$, from a single input X. Any point that is off the PPC is said to be an inefficient point, for example, point A. Point B however, is efficient and the distance AB shows the technically inefficient point. At this point, an extra input is not needed to increase the output amount, for it to reach its optimum level. Technical efficiency can therefore be given by the ratio $\frac{OA}{OB}$.

The importance of this study can be found in (Farrell, 1957) who speaks on the importance of the productive efficiency of industries in an economy for its economists, and its policy makers. For makers of policies, they need to know by how much an industry can be expected to have its output increased, given the level of inputs being used at the moment, by increasing its efficiency. This will help the economic planning for these industries. He states an assumption that the firm is experiencing constant returns to scale to be able to use a basic isoquant diagram as shown above in figure 2.1. He used this diagram to explain price efficiency and technical efficiency, which, together, would explain the overall efficiency of a firm.

The output orientation measure was shown by(Coelli et al., 2005). (Luvanda et al., 2010)**,** also put this method to use and called it the one output or multi-input method to discover the relationship connecting the size of a firm to its level of technical efficiency for the manufacturing firms in East Africa. It used a representative sample of Kenyan, Ugandan, and Tanzanian agricultural manufacturing firms. This is a method where the inputs of a firm are held constant and we quantify how possible it is to increase output. This is the method that will be applied here.

### 2.2 Empirical Literature Review

It is crucial to analyze not only the efficiency of firms, but industries as well to gain a better grasp of the factors causing the inefficiencies therein. With the analysis of efficiency gaining a large amount of recognition over the past 40 years, and many factors come up often, as the causes of inefficiency, as well as areas that can be improved for firms to improve their efficiency levels.

The size of a firm has been proven through empirical analysis to have an effect on its technical efficiency that is positive. This has been attributed to the explanation that larger sized firms tend to have a level of technical efficiency that is higher when compared to that of firms that are smaller

in size, (Jovanovic, 1982), (Chen & Tang, 1987), and (Ismail et al., 2014). This was also found to be true by (Oczkowski & Sharma, 2005) who did a study to analyze the factors that influence the level of efficiency in LDCs and gathered their evidence from Nepalese manufacturing firms. This evidence was consistent with the majority of the literature as it implied that there are cost benefits that a firm gets due to an increase in their scale of operation or economies of scale. (Luvanda et al., 2010) used data that had been collected by the World Bank, as part of their Investment Climate Survey in 2002 – 2003 to ascertain the relationship between a firm's level of technical efficiency and its size, for East African manufacturing enterprises that is firm in, Kenya, Uganda, and Tanzania. They applied the DEA model to the data and found that this relationship in Kenya and Uganda, is U shaped. This meant that when a firm was still small and young, it benefited from the fewer regulations by the government and thus was able to operate in a technically efficient way. This reduced as the firm size grew. Larger sized firms benefited due to their economies of scale and thus the technical efficiency of these firms was high as well. (Lundvall & Battese, 2000) concluded from their study of Kenyan manufacturing firms, that a firm's size had an effect on its level of technical efficiency which was positive, provided that the firm had surpassed a given age threshold, that being 5 years. Some studies have shown that the relationship between a firm's level of technical efficiency and its size is negative, contrary to theory and the studies mentioned above, including (Uwacu, 2019), (Widodo et al., 2015). While someone might argue that the key to increasing the technical efficiency levels for infant firms may be to protect them from foreign markets and international competition, (Karunaratne, 2012) prove in their work that this does more harm than good and that the firms that are left unprotected end up having higher levels of technical efficiency than the protected firms.

(Jovanovic, 1982) Explains that a firm's age has a positive relationship with its level of technical efficiency, which has been cited and used as a blueprint by a large amount of literature. He goes on to show that in order for a firm to grow in size, it must have been in operation for a significant number of years; thus, these large firms are also older, and thus, a firm's age is positively related to efficiency. These larger firms also have larger networks, a widespread reputation, and access to competitive foreign markets, so they must be efficient to survive in this environment. (Cheruiyot, 2017) Carried out a Data Envelopment Analysis of the World Bank Enterprise Survey Data of 2007 established that younger firms in Kisumu and Nairobi, had a level of technical efficiency that was higher than that of the older firms, and this, therefore, discredits the theory by (Jovanovic,

1982) as well as the theory of learning-by-doing, since apparently, the negative effects of aging of a firm outweigh the positive effects. Younger firms also tend to be more aggressive, flexible, and proactive as compared to older firms and this could be a reason that makes them more efficient than larger firms. This was not the case for firms in Nakuru and Mombasa, where the older firms happened to have a higher level of technical efficiency than the younger firms. (Uwacu, 2019) in her analysis of Rwandan manufacturing firms found that the age of a firm had a relationship that was significant and positive with its level of technical efficiency and so did (Widodo et al., 2015). (N. E. Tingum, 2014b) Analyzed the level of technical efficiency and the Cameroonian manufacturing exports' performance, and found that firms that were aged between 5 years to 20 years were more efficient than the rest. This was because the employees and managers of these firms gained more experience as the firms stayed in operation.

(Uwacu, 2019) in her study of the technical efficiency of the manufacturing enterprises in Rwanda, using data from the Rwanda enterprise Census of 2017 which covered 14,013 manufacturing enterprises in Rwanda, found that firms that were owned domestically had a relationship that is positive with technical efficiency. (Pitt & Lee, 1981) Applied the Stochastic Frontier Analysis methodology to evaluate the factors that influence the level of technical efficiency in the Indonesian weaving industry with data being time series data as well as cross-sectional data for individual firms, and they concluded that foreign firms would produce only 48.6% of output as compared to their domestic owned counterparts. But if we consider other factors, that is, that firms owned by foreigners are bigger and newer than the firms owned domestically, then their technical efficiency rises to 84.2%. (Singh et al., 2019) believes that technological up-gradation for industries in the Indian manufacturing sector will enable them to increase technical efficiency through an increase in production activities. (Cheruiyot, 2017) also established from the 2007 World Bank Regional program for Enterprise Development survey data for Kenya, that the firms owned domestically were less efficient than the firms owned by foreigners, having their technical efficiency levels at 67.7% and 69.1% respectively. He attributes this difference to the transfer of managerial skills, information on the market, and technical know-how internationally. This was also found to be true by (E. N. Tingum & Ofeh, 2017).

(Charoenrat et al., 2013) Explored the level and factors influencing the level of technical efficiency of SMEs in Thai manufacturing firms, and found that the level of skilled labour, in general, does have a relationship with technical efficiency that is positive. The data used was cross-sectional and

was from the 2007 manufacturing SMEs census in Thailand. (J. M. Page, 1980) While trying to discover clearly how the level of technical efficiency interacts with economic performance in Ghana, used SFA, to analyze the data of three Ghanaian industries and found that the industry experience of managerial staff, paired with the formal training that they received before assuming the managerial positions, had a relationship which was positive with technical efficiency. In that, the firms with the managers that were without training or prior experience had low levels of technical efficiency in comparison with the firms with managers who had both. (Admassie & Matambalya, 2002; Lundvall & Battese, 2000) also found this to be true. (Ismail et al., 2014) While studying the level of technical efficiency for SMEs in Malaysia also concluded in their study, that the decision to hire workers in the lower ranks by SMEs so as to save costs, affected the level of technical efficiency negatively. Thus, firms hiring skilled labor was necessary for an improved technical efficiency level.

(Singh et al., 2019) Investigated and found that the proportion of revenue that a firm receives from exporting its products against its total outputs does have relationship with technical efficiency that is positive for Indian manufacturing firms. (Granér & Isaksson, 2009) Used a panel data-set with a sample consisting of 276 firms in the Kenyan manufacturing sector between the years 1992 and 1994 collected by the World Bank, and analyzed it using as they investigated the manufacturing sector in Kenya for links between the exports in this sector and technical efficiency, found that the firms which exported their products were inclined to be more efficient than those that did not export their products. And for exports to be outside Africa, the firms needed to be bigger, while for exports within Africa, it required that firms have a production that is intensive in both physical and human capital.

(Singh et al., 2019) Applied the Stochastic Frontier production function approach to examine primary data that they collected from seven different industries, auto-components and automobiles, chemicals and petrochemicals, construction, industrial equipment and machinery, electronics, textiles and apparel, and finally, pharmaceuticals, which are in the manufacturing sector. They obtained information from 154 manufacturing institutions in total which they analyzed to evaluate the level of technical efficiency of the firms in the manufacturing sector in India. Here, they established that all of the industries excluding textiles and apparel had a technical efficiency of more than 94%.

(Cheruiyot, 2017) Estimated the level of technical efficiency of Kenyan manufacturing institutions with data from the 2007 Kenyan Regional program for Enterprise Development survey data by the World Bank and analyzed this data using the two stage nonparametric approach variation of the Data Envelopment Analysis. Here, it was established that the firms that were most efficient were those in the chemicals and pharmaceuticals sector. (Chirwa, 2001) attributed the variance in the technical efficiencies of different industries to the variations in qualities that are specific to those firms and industries. (Lundvall & Battese, 2000) analyzed manufacturing enterprises in Kenya and covered four sectors namely, the textile, wood, food, and metal sectors. They used data observed from 1993 to 1995. They compare the effects of technical efficiency on firms in different industries. (Dinh et al., 2020) Estimated the technical efficiency level for small-scaled manufacturing firms within 6 different industries in Vietnam, using primary data they obtained from June 2019 to August 2019. From their results, the study team suggested that for small-scaled enterprises to increase their technical efficiency, they would be required to improve the quality of labor they employ in their operations, the technology of production and most especially, the quality of their input materials, especially in the textiles and garments sector, the building materials sector and the food processing sector. In doing so, these enterprises would shift their production frontier upward.

Research and development is a way for firms to introduce new and innovative modes of operation within their production and operation processes. (Le et al., 2018) using survey data at the firm level collected in 2008, and analyzing it with a stochastic meta-frontier model found that incorporating activities pertaining to research and development in the production process of Vietnamese small and medium manufacturing firms had a relationship with technical efficiency that was positive. In contrast, (Barasa et al., 2018) established that a firm that employs research and development activities in its production processes, especially in developing countries, tends to have technical efficiency that is at a lower level compared to those that do not embrace research and development activities. They found that research and development alone, or introduction of foreign technology alone was not enough to influence technical efficiency positively. They needed to be undertaken together to ensure that there was a rise in the level of technical efficiency. The research and development provided absorptive capacity which in turn enhanced the influence that foreign technology had on technical efficiency.

While investigating the influence that R&D intensity and its spillovers assert on the level of technical efficiency for the Turkish manufacturing firms, (Kalaycı & Pamukçu, 2014) found that for firms in operation with low levels of technology, the effect of R&D intensity and R&D spillovers was not statistically significant, and the opposite was true for the high and mid technology firms. (Ismail et al., 2014) While analyzing the level of technical efficiency for Malaysian SMEs, pointed out the importance of expenditure on R&D in reducing inefficiencies within the firm and increasing efficiency, and thus the research team concluded that it was important for firms to increase this type of expenditure.

A firm's location can influence its level technical efficiency and this is shown by (Cheruiyot, 2017) who upon studying the different elements affecting the technical efficiency of manufacturing institutions in Kenya, found that firms in Nairobi (69.3%), Kisumu(70.2%) and Nakuru (71.1%) showed that they had higher levels of technical efficiency than their counterparts in Mombasa (64.5%). This is due to production cost differences in these counties. Nakuru was leading in this list, with firms having an average of 71.1% technical efficiency levels and this is attributed to the labour costs there being cheaper than those in Nairobi, Kisumu, or Mombasa. (Widodo et al., 2015) talks about agglomeration which refers to when economic activities are concentrated in a limited area. From their findings, they found that when the firms are concentrated in one area, then there is an increase in the competitiveness of the business and this causes them to have increased levels of technical efficiency than the firms in areas that have low levels of competition. This means that monopolistic firms together with oligopolistic firms possess low levels of technical efficiency.

### 2.3 Overview of Literature

Economic growth, especially in developing countries relies on industrialization as one of the roads to becoming developed countries. Studies like (Battese & Coelli, 1995; Tybout, 2000) emphasize the importance of industrialization, especially in increasing the technical efficiency levels of firms in the manufacturing sector. In Kenya, this sector has been included in the majority of the economic development blueprints, the Vision 2030, the Constitution, and the Big 4 Agenda by the Jubilee government. This shows the importance that has been bestowed upon it. However, it does face major challenges that make it stagnate and also make it difficult to achieve the goals that have been set before it. These factors are both exogenous and endogenous. The endogenous factors affecting

the level of technical efficiency of firms are what this study focused on. There have been parametric approaches to calculating the technical efficiency, that is SFA which has been utilized by (Islam et al., 2016; Lundvall & Battese, 2000; Oczkowski & Sharma, 2005; Uwacu, 2019; Widodo et al., 2015), and non-parametric approaches, as in DEA which has been used by**,** (Cheruiyot, 2017; Chirwa, 2001; Luvanda et al., 2010) and many more other studies. Which have found the following factors affecting the levels of technical efficiency of manufacturing institutions, the size of the firm, the age of the firm, the managerial experience of the top executive, the structure of ownership, the exporting status of the firm, the location of the firm, the industry the firm is in, and finally, the technological innovations that have been adopted by a firm. This study made use of the SFA model to analyze the data and find the different effects that these factors have on the firms in different industries and also compare the intensity of their influence or their importance in these industries too. The industries that were looked at include metal, food, textile, and garments. This study also contributed to the existing literature by conducting a cross-sectional analysis of only manufacturing institutions in Kenya using the most recent data from the World Bank Enterprise Survey Data of 2018. Policymakers will be better informed about the areas of efficiency that need improvement in Kenya's manufacturing sector as a result of the study's findings, which will increase productivity.

# CHAPTER THREE
# METHODOLOGY

## 3.0 Introduction

The two competing methods for measuring efficiency are Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) (SFA). The Stochastic Frontier Analysis, a parametric approach, was used to analyze this data and that is following (Coelli et al., 2005) and (Lundvall & Battese, 2000). By being parametric, it is required in its analysis, to take up a specific functional form, among other assumptions. When compared to DEA, SFA is better as it accounts for the noise, or random effects (Barasa et al., 2018).

SFA takes into account two extreme assumptions of the productivity theory. The first one is that, if the data suggests that the inefficiency term is statistically insignificant, then this will be treated as the neoclassical approach where the production units are fully efficient, and therefore, one can go ahead and undertake the standard regression procedures. The other extreme is that the statistical noise does not exist, and all the deviations within the model are brought about by inefficiency. With this, accounting for inefficiency is very crucial before coming up with quantitative or qualitative solutions with policy implications. The Stochastic Frontier Analysis (SFA) can provide a middle ground between these extreme assumptions, but it also allows for them to be accommodated as special cases if the data suggests so (Kumbhakar et al., 2012).

## 3.1 The Stochastic Frontier and Inefficiency Model

The benefits of using this method of analysis are threefold and are explained below. To begin with, the SFA can provide a structure to figure out the causes of inefficiency in production and the causes of varying levels of productivity which are of great use while making conclusions about how inefficiency can be reduced and productivity increased. Meaning that it is built upon a functional form that is well specified (Aigner et al., 1977). (Barasa et al., 2018). Finally, the SFA model differs from a normal production function in that it has two error terms, one representing stochastic shocks or random effects and the other representing inefficiency. With this in mind, the SFA yields a parameter. Second, SFA makes it possible to employ classical estimation techniques such as the Maximum Likelihood Estimation (MLE) and Likelihood Ratio (LR) tests that are void of measurement error and thus it proves to be a more suitable approach for hypothesis testing (Coelli et al., 2005; Uwacu, 2019).

The SFA is made up of three parts: a deterministic production function, a random effects error term, and an inefficiency error term.

We begin by considering a production function for the frontier of a given firm, say the *i*th firm, that is,

$$y_i = f(x_i; \beta). \quad (1)$$

Here, $y$ represents the maximum output that is attainable by firm $i$, using $x_i$ as an inputs vector, and $\beta$ which is a vector of the parameters to be projected. Here the firm can be said to be on the production frontier.

But since with SFA, a firm can either be on the production frontier or below it (Aigner et al., 1977), then the function for parametric production frontier with cross-sectional data for a firm, can be expressed as;

$$y_i = f(x_i; \beta).TE_i \quad (2)$$

With the term $f(x_i; \beta)$ being the production frontier, (Coelli et al., 2005) shows that it has to be deterministic. This means that it depends on the number of inputs used in production as well as a technological factor that is included in the parameters vector, $\beta$. The TE stands for technical efficiency, which, as previously stated, is the ratio of a firm's actual output to its maximum possible output. It represents a firm's technical efficiency and can be said to be;

$$TE = \frac{y_i}{f(x_i;\beta)} \quad (3)$$

Efficiency estimations of a firm earlier were largely of the non-deterministic type. Then (Farrell, 1957a) came in and introduced a deterministic component that was specified as follows;

$$y_i = f(x_i; \beta).\exp(-u_i) \qquad u_i \geq 0 \quad (4)$$

The disturbance term, $u_i$ is non-positive and this is to show that the output of every firm in the study, can only lie on the frontier or below it (Aigner et al., 1977). Also, for all $u_i$ the technical efficiency ranges between zero and 1. They also claim that the disturbance is caused by factors within the firm's control as well as the firm's and its employees' efforts. The frontier, however, can vary within the firm at different periods as well as, from firm to firm.

From this, (Battese & Coelli, 1995) contributed to the following equation, which shows the maximum possible output from firm *i* that can be produced from a set of given inputs;

$$y_i = \exp(x_i\beta + v_i - u_i) \quad (5)$$

Where $v_i$ represents the random effects error. It represents the factors influencing the firm's performance that are beyond the firm's control. This includes both measurement and observational errors.

This error term is symmetric with a mean of zero, $v_i \sim N(0, \sigma_v^2)$. The technical efficiency error $u_i$ is assumed to be independent and identically distributed from $v_i$.

A truncated normal distribution is specified in a one-step approach for the inefficiency term's model specification. The two-step approach is ineffective because the results are skewed, and; $v_i \sim N^+(0, \sigma_u^2)$.

To describe the level of inefficiency of a firm with the assumption that $u_i \sim N^+(0, \sigma_{ui}^2)$, (Aigner et al., 1977) suggested the use of explanatory variables $(z)_i$ together with $(\alpha)$ an unknown vector of coefficients.

Therefore, the model of technical inefficiency can be analyzed as follows;

$$u_i = \alpha z_i + w_i \quad (6)$$

Here, the term $w_i$ shows a random variable that is stated via the truncation form which has a mean of zero and a variance of $\sigma^2$, by the normal distribution. The implication of this is that, with the assumption of a $u_i$ that a non-negative truncation of the distribution $N(0, \sigma_v^2)$ then the truncation goes ahead to be specified as $-\alpha z_i$.

With the assumptions of $v_i$ and $u_i$ that have been stated above about them being independent and identically distributed for a firm $i$, then to encapsulate the technical efficiency effects, the following stochastic frontier model is defined;

$$TE_i = \frac{y_i}{f(x_i,\beta)} = \exp(-u_i) = \exp(-z_i\alpha - w_i) \quad (7)$$

### 3.2 Model Specification

(Aigner et al., 1977) Proposed using the SFA model to obtain the technical efficiency of manufacturing institutions. Then (Battese & Coelli, 1995) showed how this model can also be put to use to determine the factors that cause this level of technical efficiency. This study used both of these works to determine the technical efficiency level of Kenyan manufacturing firms, as well as the factors that influence this level of technical inefficiency.

The explanatory variables that were considered included the following; the size and age of the firm, the managerial experience of the top executive, the structure of ownership, the exporting status of the firm, the location of the firm, the industry the firm is in, and finally, the technological innovations that were adopted by a firm. The model that was specified was a log-production function of the Cobb-Douglas form;

$$\ln(Y)_i = \beta_0 + \beta_1 \ln(K)_i + \beta_2 \ln(L)_i + v_i - u_i \quad (8)$$

This study proceeded as follows to analyze the inefficiency effects model:

$$u_i = \alpha_0 + \alpha_1 \ln(Age)_i + \alpha_2(Size)_i + \alpha_3(MExp)_i + \alpha_4(Oship)_i + \alpha_5(Expo)_i + \alpha_6(Loc)_i + \alpha_7(Ind)_i + \alpha_8(R\&D)_i + w_i \quad (9)$$

Where, $Y_i$ represents the annual output of a firm $i$ in Kenya, $K_i$ represents the total value of both the fixed and current assets employed in the production process, and $L_i$ represents the value of the input labour. The coefficient $\alpha$ was used in the model to show the share of each independent variable.

The inefficiency effects model was implemented and simultaneously estimated in this work using the Method of Maximum Likelihood (MML), where the independent variables or exogenous variables are in charge of explaining the inefficiency effects (Belotti et al., 2013). The one step strategy is preferable than the two step approach, according to (Barasa et al., 2018), where the stochastic frontier estimation came before the second step of calculating the inefficiency scores. They go on to say that the two-step approach has had several weaknesses, including a failure to take into account environmental factors because it was assumed that the effects of inefficiency would be distributed equally and independently. Additionally, in the second phase, the assumptions of the independent and uniform distribution of the inefficiency effects are inconsistent with the core principle that inefficiency effects are truly a function of firm-specific characteristics.

(Diaz & Sanchez, 2008) are among the studies that used the one-step methodology. As a direct consequence, the truncated normal distribution is the one that is employed.

***Age*** Indicates the age of the firm. (Barasa et al., 2018; Uwacu, 2019) Demonstrate a positive relationship between a firm's age and technical efficiency, and that older enterprises in the same industry have levels of technical efficiency that are higher than that of the younger ones.

***Size*** Represents the size of the firm. (Oczkowski & Sharma, 2005; Widodo et al., 2015) have proven that a firm's level of technical efficiency and its size have a positive relationship. The number of employees employed by a company was used to determine the size of a firm in this study, which categorized firms as micro, small, medium, and large.

***MExp*** Represents the degree of experience of a firm's managerial staff and is measured by the amount of years that the top executive has spent working in the industry in which the firm operates. (Admassie & Matambalya, 2002; J. M. Page, 1980) Findings have demonstrated that the amount of experience a top executive possesses has a positive relationship with the firm's technical efficiency.

***Oship*** This is concerning the ownership structure of a firm that is, whether it is owned by a foreigner or by a Kenyan. Foreign owned firms have been seen to have higher levels of technical efficiency by previous literature (Cheruiyot, 2017).

***Expo*** This shows the export status of the firm. That is, whether it exports its products or not. (Granér & Isaksson, 2009; Singh et al., 2019) established in their work, that the proportion of a firm's revenue derived from exports is positively related to technical efficiency. Firms that sell their goods internationally are often more technically efficient compared to those that do not.

***Loc*** Indicates the location of the enterprise. Whether the firm was located in Nakuru, Nairobi, Kisumu, or Mombasa. (Cheruiyot, 2017) in their study indicate the importance of the location of the manufacturing industry in Kenya in its technical efficiency.

***Ind*** Represents the industry to which a firm belongs. This exemplified the disparity in overall levels of technical efficiency among firms in various manufacturing industries. (Singh et al., 2019).

***R&D*** This is to determine whether or not a firm's decision to engage in research and development activities for their operations has any overall impact on the firm's level of technical efficiency. (Le

et al., 2018) found that incorporating activities pertaining to research and development in the production process had a relationship with technical efficiency that was positive.

## 3.3 The Description and Measurement of Variables

**Table 1: Variables and their Description**

| **Variable** | **Measure** |
|---|---|
| | **Production Frontier** |
| Output (Y) | It was highlighted as a measure of the previous fiscal year's total sales value for the company. |
| Capital (K) | The total annual expenditure on equipment, land, and buildings in the previous fiscal year. |
| Labour (L) | The overall number of people employed at the firm on a permanent full-time basis at the end of the previous fiscal year. |
| | **Explanatory variables** |
| Age | This is the duration of time that the firm has been in business. It is calculated as the number of years from when the firm began operations to the year the survey was taken (2018). |
| Size | This has been depicted in the study by the overall number of people employed in the organization on a permanent full-time basis. Where 1-19 indicated that the firm is small, 20-99 indicated that the firm is medium, and 100+ indicated that the firm is large. |
| Managerial Experience (MExp) | Represents the degree of experience of a firm's managerial staff and is measured by the amount of years that the top executive has spent working in the industry in which the firm operates. |
| Ownership Structure (Oship) | This is used to indicate whether a company is owned by a foreigner or a domestic company. It was measured using a dummy variable, with 1 indicating that the firm was owned by a foreigner and 0 indicating that it was not. |

| | |
|---|---|
| Exporting status (Expo) | This measures whether the firms export their products or not. This was also measured by a dummy variable, where it was 1 if the firm exported its products and 0 otherwise. |
| Location (Loc) | This is the location of the manufacturing firm, whether it is in Mombasa, Nairobi, Nakuru, or Kiambu. Each location was represented by a dummy variable, where 1 was whether the firm was in that location and 0 otherwise. |
| Industry (Ind) | Other manufacturing includes the production of wood and wood-derived items, excluding furniture, as well as the production of coke and refined petroleum products, straw-based products, non-metallic mineral products such glassware, electronics, computers, and optical goods. A dummy variable had been used to measure each industry, with 1 indicating that the firm was in that industry and 0 signaling that it was not. |
| Research and Development (R&D) | This indicates whether research and development activities were conducted by the company in the previous fiscal year. It was measured by a dummy variable, where 1 meant that the firm did engage in research and development activities in the last financial year and 0 otherwise. |

### 3.4 The Source of Data and Data Type

The most recent data available for all manufacturing firms in Kenya is in the World Bank Enterprise Survey Data for 2018, which was used in this study. This data reports on various indicators of technical efficiency for individual firms and industries, as well as information on the qualitative and quantitative characteristics of these manufacturing firms. Technological innovations that it has adopted.

# CHAPTER FOUR
# RESULTS AND DISCUSSION OF FINDINGS

## 4.0 Introduction

In this chapter, a discussion of the results and findings after the analysis of data is featured. This study applied the stochastic frontier analysis to 2018 data from the World Bank on Kenya's manufacturing institutions, to determine their technical efficiency. Here, the inefficiency term was distributed through the truncated normal distribution and the output oriented measure of technical efficiency was observed. The sections that follow have been ordered as follows; 4.1 provided a meticulous review of the descriptive statistics of the study's variables, 4.2 presented at the correlation analysis, and 4.3 presented at the econometric results.

## 4.1 Descriptive Statistics

The purpose of this was to gain better insight and understanding of the variables before going further to analyze and investigate the technical efficiency level for manufacturing firms in Kenya, and the factors that caused this level of technical efficiency. The table below, Table 2, exhibits the summary statistics for the study's explanatory variables as well as the variables that make up the production frontier.

**Table 2: Summary Statistics**

| VARIABLES | mean | sd | min | max |
|---|---|---|---|---|
| Output | 863.90 | 13,620.0 | 0.10 | 425,000.00 |
| Number of workers | 73.97 | 252.9 | 1 | 6,000 |
| Capital | 7,260.00 | 87,820.00 | 0 | 1,710,000.00 |
| age | 22.23 | 18.35 | 0 | 124 |
| Experience | 15.97 | 11.74 | 0 | 65 |
| D_foreign | 0.103 | 0.304 | 0 | 1 |
| D_export | 0.191 | 0.393 | 0 | 1 |
| dummy_Rdev1 | 0.192 | 0.394 | 0 | 1 |
| **Dummies for location | | | | |
| D_Mombasa | 0.0939 | 0.292 | 0 | 1 |
| D_Kiambu | 0.106 | 0.308 | 0 | 1 |
| D_Nakuru | 0.0999 | 0.300 | 0 | 1 |
| D_Nairobi | 0.305 | 0.461 | 0 | 1 |
| **Dummies for Industry | | | | |
| D_food | 0.160 | 0.367 | 0 | 1 |
| D_TextilesGarments | 0.0599 | 0.237 | 0 | 1 |
| D_OtherMfg | 0.188 | 0.391 | 0 | 1 |
| D_chempharmaplastics | 0.112 | 0.315 | 0 | 1 |
| **Dummies for size | | | | |
| D_small | 0.404 | 0.491 | 0 | 1 |
| D_medium | 0.333 | 0.471 | 0 | 1 |
| D_large | 0.202 | 0.402 | 0 | 1 |
| *Summary statistics of the logarithmic form of the stochastic production frontier. | | | | |
| lnoutput | 17.54 | 2.249 | 11.51 | 26.78 |
| lncapital | 14.90 | 2.441 | 9.210 | 22.33 |
| lnlabour | 15.46 | 2.055 | 10.71 | 22.33 |

The means, minimum and maximum values, and standard deviations for all variables included in the study, that is, those in the production frontier as well as those affecting technical efficiency, have been examined here. From the table 2 we observe that only 10% of the manufacturing firms in Kenya are owned by foreign individuals and companies thus, a majority of the manufacturing firms in Kenya are owned either domestically or jointly, by a foreign entity and a domestic entity. Research and development plays an indispensable role in the growth of a firm and still from the data, only 10% of Kenyan manufacturing firms apply research and development activities in their operations. Also, only 19% of the manufacturing firms in Kenya sell the goods they produce to foreign countries.

According to World Bank data, a firm's size is categorized based on the number of employees on a permanent and full-time basis within the firm, and thus the classification is medium enterprises, large enterprises, and small enterprises. From the World Bank data, we can see that about 40% of the manufacturing firms in Kenya are small meaning that between 1 to 19 employees are working in the firm, and 33% are medium sized meaning that they have between 20 to 99 employees working at the firm, and 20% are large manufacturing firms which have 100 or more employees. The manufacturing firms operate in different industries within the sector, but for those industries that were looked at, 16% of the firms are in the food industry, 5% were in the textiles and garments industry, 11% were in chemicals, pharmaceuticals, and plastic and the firms in other manufacturing took up 18.8%.

Regarding the location of the firm, Nairobi hosts 30.5% of the manufacturing firms in Kenya, eventuating in it being the county with the highest concentration of manufacturing firms in Kenya. Kiambu County comes in second with 10.6% of the firms, Nakuru with 9.9%, and then Mombasa with 9.3% of the firms. The number of years, on average, that a Kenyan manufacturing firm has been up and running, is about 22 years, with the oldest firm being 124 years in operation in Kenya. On average as well, the experience of a top manager of a manufacturing firm in Kenya, in the industry in which the firm operates has been shown by the data to be 15 years, and the highest number of years in experience was recorded to be 65years.

### 4.2 Correlation Analysis.

This is to determine whether the variables have a weak or strong correlation. The pairwise correlation was used in this case. The results for this have been laid out in Table 3. Here, we observe that the correlation between the variables was weak and thus the problem of multicollinearity was not experienced in the model estimation.

**Table 3: Pairwise Correlation**

| Variables | lnoutput | lncapital | lnlabour | lnage | lnexp | D_foreign | D_Export | D_Rdev1 |
|---|---|---|---|---|---|---|---|---|
| lnoutput | 1.000 | | | | | | | |
| lncapital | 0.674 | 1.000 | | | | | | |
| lnlabour | 0.160 | 0.328 | 1.000 | | | | | |
| lnage | 0.337 | 0.289 | 0.245 | 1.000 | | | | |
| lnexp | 0.347 | 0.303 | 0.243 | 0.399 | 1.000 | | | |
| D_foreign | 0.180 | 0.149 | 0.162 | 0.031 | 0.025 | 1.000 | | |
| D_export | 0.359 | 0.243 | 0.384 | 0.131 | 0.176 | 0.195 | 1.000 | |
| D_Rdev1 | 0.146 | 0.174 | 0.163 | 0.057 | 0.048 | 0.002 | 0.119 | 1.000 |

### 4.3 Results from Model Estimation.

The main goals of this study were to approximate the technical efficiency level for Kenyan manufacturing firms and to analyze the factors that influence this technical efficiency level for Kenyan manufacturing firms. The Stochastic Frontier Analysis approach was employed to achieve these two objectives, and the results have been displayed in Table 4.

#### 4.3.1 Results from Estimation of the SFA model.

The Statistical Frontier Analysis approach has to make several assumptions as it constructs a production frontier from the efficient firms which have all the inefficient firms below it. The first assumption that is made is that the production function used is well founded to be used by every firm. Next, is that the technology of production is also assumed to be similar for every firm, insinuating that the production technology is homogenous. These assumptions are derived from the Maximum Likelihood Estimation of the Stochastic Frontier Analysis model, as well as the model estimation for inefficiency effects, namely the estimation of equation (8) and the estimation of equation (9).

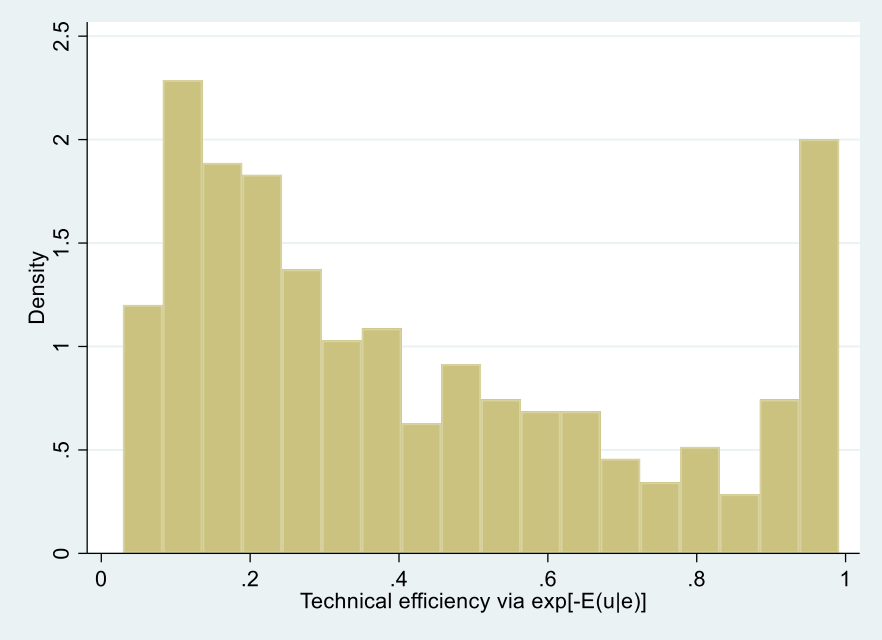
For the first objective of the study, the results exhibit that the mean level of technical efficiency for the manufacturing firms that were analyzed was 0.4254 which is about 42.5%, as seen in table 4. This was estimated through the (Battese & Coelli, 1988) technical efficiency estimator, that is $E[Exp(-u|\varepsilon)]$. This means that on average, a manufacturing firm in Kenya operates below its maximum level of potential output by 57.5%. In comparison, (Karunaratne, 2012) while analyzing the technical efficiency of manufacturing firms in eight industries in Australia, over a period of 26 years, established that the firms were operating at a level that was 19% below their optimal level of production, that is, 81% level of technical efficiency. (Tingum, 2014) Established that for Cameroonian manufacturing firms, the average level of technical efficiency was 63.4% and (Granér & Isaksson, 2009) found that between 1992 and 1994, the technical efficiency level for Kenyan manufacturing firms was 55% on average.

Figure 4.3.1 also depicts the distribution of technical efficiency levels among Kenyan manufacturing enterprises, demonstrating also that a significant proportion of these firms operate at a degree of technical efficiency that is below the average.

**Table 4: Estimation of the technical efficiency of manufacturing firms in Kenya.**

| VARIABLES | mean | Std dev. | min | max |
|---|---|---|---|---|
| **Output** | .4254639 | .3001363 | .0290439 | .9914432 |

**Figure 4.3.1: The Distribution of the Levels of Technical Efficiency of Kenyan Manufacturing Firms.**




### 4.3.2 Factors that determine the level of technical efficiency of manufacturing firms in Kenya

This section addresses the study's second objective. The Stochastic Frontier parameter is presented and explained, as well as the inefficiency effects model. Table 5 shows the results of the Stochastic Frontier Analysis estimation, as well as the factors influencing the technical efficiency level of 327 Kenyan manufacturing enterprises.

**Table 5: Estimation of the Stochastic Frontier Analysis using Maximum Likelihood regression.**

| **SFA Results** | **Model** | | | |
|---|---|---|---|---|
| Variables | Coeff. | Std. error | z | P-value |
| **Frontier** | | | | |
| lncapital | .2406398 | .0396299 | 6.07 | 0.000 |
| lnlabour | .5523269 | .0541984 | 10.19 | 0.000 |
| Constant | 6.277083 | .8331271 | 7.53 | 0.000 |
| **Determinants of inefficiency** | | | | |
| lnage | -.1629173 | .1072882 | -1.52 | 0.012 |
| lnexperience | -.5169018 | .1357085 | -3.81 | 0.000 |
| Dummy_foreign | .4881415 | .3452751 | 1.41 | 0.157 |
| Dummy_export | -.4619275 | .3026377 | -1.53 | 0.127 |
| Dummy_Rdev | -.0888265 | .2148061 | -0.41 | 0.679 |
| **Size of the firm** | | | | |
| Dummy_small | .9120859 | .4182455 | 2.18 | 0.029 |
| Dummy_medium | .4844157 | .4215752 | 1.15 | 0.251 |
| Dummy_large | -.5300202 | .5973706 | -0.89 | 0.037 |
| **Location of the firm** | | | | |
| Dummy_Mombasa | -.0193574 | .5598602 | -0.03 | 0.972 |
| Dimmy_Kiambu | -.8103243 | .3817203 | -2.12 | 0.034 |
| Dummy_Nakuru | .0014037 | .2912089 | 0.00 | 0.996 |
| Dummy_Nairobi | .3124948 | .2432603 | 1.28 | 0.199 |
| **Industry the firm belongs** | | | | |
| Dummy_Food | -.2864071 | .278169 | -1.03 | 0.303 |
| Dummy_TextilesGarment | .883261 | .3646406 | 2.42 | 0.015 |
| dummy_OtherMfg | .2929753 | .263322 | 1.11 | 0.266 |
| dummy_chempharmaplastics | -.0053891 | .3038509 | -0.02 | 0.027 |
| Constant | 1.886866 | .5238834 | 3.60 | 0.000 |
| Usigma | -5.402002 | 3.184844 | -1.70 | 0.090 |
| Vsigma | .4276797 | .0783645 | 5.46 | 0.000 |
| sigma_u | .0671383 | .1069125 | 0.63 | 0.530 |
| sigma_v | 1.238424 | .0485242 | 25.52 | 0.000 |
| Number of observations | 327 | | | |
| Wald chi2(2) | 273.29 | | | |
| Prob > chi2 | 0.000 | | | |
| Log likelihood | -534.2347 | | | |

Source: Computations by the author from World Bank Enterprise Survey Data (2018)

According to the results in Table 5, the estimated model is overall well-fit. The overall p-value is 0.000, indicating that it is statistically significant. Furthermore, at the 1% level of significance, the coefficients of the production frontier's inputs are positively and statistically significant.

Following interpretations of the determinants of the inefficiency effect model coefficients given by (Belotti et al., 2013), the study takes it that a coefficient possessing a positive sign denotes that a firm's inefficiency is increasing and decreasing if it possesses a negative sign. It can also be said that a coefficient possessing a positive sign reveals that the factor negatively influences technical efficiency, and coefficient possessing a negative sign illustrates that the factor positively influences the level of a firm's technical efficiency.

The size of a firm is classified according to the number of employees it has. From our results, the small firms' coefficient is positive and is also statistically significant, the medium sized firms' coefficient is positive and is statistically insignificant, and the large firms have a negative coefficient that is statistically significant as well. This is in line with (Jovanovic, 1982), (Chen & Tang, 1987), and (Oczkowski & Sharma, 2005) who all concluded in their studies that firms which are larger in size, are prone to have a level of technical efficiency that is higher compared to firms which are smaller in size. (Jovanovic, 1982; Tingum, 2014) Attributed this to several factors including, a selection process that occurs as firms stay in operation whereby, only the efficient firms increase in size and survive in the industry while the inefficient firms end up stagnating or even leaving the industry all together. Another reason could be that large firms have better management that is more competent, as well as a higher ranking cost stricter. Both of these factors could cause a firm's market share to rise. Even though (Luvanda et al., 2010) found that small and young firms were more technically efficient since they benefitted from fewer government regulations, the majority of literature implies that there are cost benefits that a large firm gets due to an increase in their scale of operation or an increase in their economies of scale meaning, therefore, that a firm's size has a relationship with its level of technical efficiency that is positive and significant. This study, therefore, confirms that firms that are larger in size indeed operate at a level of technically efficiency that is higher than that of firms that are smaller in size.

The age of the firm in this study was calculated from the time the firm began operation until 2018, which is when the data was collected. From the results, the variable that represents age possesses a negative coefficient which is significant statistically. This is in line with the principle that older firms benefit from learning by doing over the years and thus are expected to be more efficient. (Jovanovic, 1982) Found the same in his study where he explained that the relationship between the age of a firm and its technical efficiency is positive, and since in most scenarios, it takes a firm a number of years for it to increase the number of permanent and full time employees and

consequently, to grow in size, then these large firms were also older, and therefore, the age of a firm was positively related to efficiency too. This was also found to be true by (Uwacu, 2019) in her analysis of Rwandan manufacturing firms as well as (Widodo et al., 2015).

While analyzing managerial experience, that is, exhibited by the number of years of experience the top manager possesses working in the industry in which the firm operates, was revealed to have a coefficient that was negative and statistically significant. This means that the more years the top manager had in the working in the firm's industry, the more technically efficient the firm was. This was found to be true as well by (J. M. Page, 1980), for Ghanaian industries, (Admassie & Matambalya, 2002; Lundvall & Battese, 2000), as well as (Charoenrat et al., 2013) who analyzed the level and determinants of the technical efficiency of small and medium sized enterprises in the Thai manufacturing industry and found that the level skilled labour, in general, does relate positively to the technical efficiency.

The status of ownership, whether it is owned domestically or by a foreign entity in this study was measured as a dummy variable where 1 meant that the firm was under the ownership of a foreign entity and 0 otherwise. The results showed that the coefficient was positive and statistically insignificant. This meant that firms that are owned by foreign entities have a relationship with technical efficiency that is negative. This is taken in turn to mean that firms owned domestically were more technically efficient. This is in agreement with (Uwacu, 2019) who found that firms that were owned domestically had a relationship that is positive with technical efficiency. Despite having been exposed to relatively high degrees of technological innovation, foreign-owned firms' employees may lack the capacity to absorb these innovations for increased levels of technical efficiency, as is the case with many manufacturing firms in SSA.

(Pitt & Lee, 1981) Also found this to be true for firms in the Indonesian weaving industry. But upon further investigation, they found that by considering other factors like firms under the ownership of a foreign entity being bigger and newer than firms under the ownership of a domestically entity, caused their technical efficiency to increase and exceeded that of the domestically owned firms. (Cheruiyot, 2017) Established the opposite of what was found in this study that is, the firms owned domestically were less efficient than the firms owned by foreigners. He attributes this difference to the transfer of managerial skills, information on the market, and technical knowhow internationally. In their study, (Barasa et al., 2018) highlighted the positive

relationship between firms owned by a foreign entity, and the firm's levels of technical efficiency. This was thought to be due to the transfer of intellectual resources and training of employees that occurs as a consequence of the firm being owned by a foreign entity. This, they claimed, was true for Sub-Saharan African manufacturing firms.

For the firm's exporting status, it was measured using a dummy variable where 1 meant that the firm exported some of its products and 0 otherwise. The study found that the coefficient was negative but statistically insignificant. This shows that the exporting status of a firm has a relationship with technical efficiency that is positive and is statistically insignificant. However, the relationship with technical efficiency being positive means that the firms that export their products, directly or indirectly are more technically efficient than the firms that do not. (Singh et al., 2019) Found this to be true for the manufacturing firms in India. (Granér & Isaksson, 2009) Found that in Kenya, the firms which exported their products were inclined to be more efficient than those that did not export their products. They also made conclusions that for a firm to be able to export its products outside of Africa, it needed to be big in size to cater for the high demand, and for it to export within Africa, the firm needed to be intensive in both physical and human capital. One more reason why firms that choose to export their products are more technically efficient that firms which do not is that they possess a comparative advantage.

The study also estimated the relationship that technical efficiency has with a firm's decision to participate in research and development. The coefficient for this was found to be negative and statistically insignificant. This means that the decision of a firm to undertake research and development activities in its production process is positively related to its technical efficiency. However, this result is seen to be statistically insignificant. According to (Le et al., 2018)**,** incorporating research and development activities into the production process of Vietnamese small and medium manufacturing firms had a positive relationship with technical efficiency. This is in contrast to what (Barasa et al., 2018) who established that for a firm to benefit from R&D activities, it had to be coupled with technological advancement and innovation. This was also backed by (Kalaycı & Pamukçu, 2014) who found the same to be true. Therefore, it can be inferred that, for Kenyan firms and firms in developing countries to fully benefit from research and development activities, they have to embrace technological innovation as well. Also, there is a possibility that the research and development activities being undertaken by a firm in the present may not yield benefits in the present time, but at a future time period.

The coefficients for firms in the food industry and the chemicals, plastics, and pharmaceuticals industry were negative and this was statistically insignificant. Meaning that the relationship between these two industries with technical efficiency was positive but it is statistically insignificant. (Cheruiyot, 2017) found this to be true for the chemicals and pharmaceuticals industry. For the textiles and garments industry and the other manufacturing industries, the coefficient was positive meaning that the firms in these industries had a relationship with technical efficiency that was negative and these results were statistically significant for the textiles and garments industries but statistically insignificant for the other manufacturing industries.

The coefficients for the firms in Mombasa and Kiambu were negative, meaning that the firms in these locations were positively related to technical efficiency even though the results were statistically insignificant for the firms in Mombasa, and statistically significant for the firms in Kiambu. For Kiambu, this can be attributed to the labour costs being cheaper there than in Mombasa, Nairobi and maybe even Nakuru according to (Cheruiyot, 2017). The firms in Nakuru and Nairobi, had a coefficient that was positive meaning that relationship with technical efficiency was negative. This can be attributed to high production costs in the two counties and the high cost of labour in Nairobi. This finding contradicts what (Widodo et al., 2015) found and referred to as agglomeration. This means that when an economic activity, in our case agglomeration is concentrated in one area, the increased competitiveness between the businesses causes them to have a higher level of technical efficiency.

# CHAPTER FIVE
# SUMMARY, RECOMMENDATIONS, AND CONCLUSION

## 5.1 Introduction

The summary, recommendations, and conclusion of this study have been addressed in this chapter. While keeping the study's objectives in mind, the summary and conclusion are examined. The recommendations will be generated in response to the key findings of the study.

## 5.2 Summary of the study.

Kenya, through its development blueprints, holds the manufacturing sector in high regard. The Big 4 agenda, the Kenya Vision 2030, as well as the Sustainable Development Goals, state how important the manufacturing sector is in Kenya's economy. But even as the GDP of the country keeps increasing, the share of manufacturing in it keeps reducing meaning that the sector's outputs remain the same or are on a decline. As a direct consequence, this research evaluated cross-sectional data from the 2018 Enterprise Survey data for Kenyan manufacturing firms in order to estimate the level of technical efficiency at which they operate, as well as the variables that influence this level of technical efficiency for these Kenyan manufacturing firms.

The study's first specific goal was evaluated using a sample of 327 firms and it was established that .4254639 was the degree of technical efficiency of Kenyan manufacturing firms which is approximately 42.54%. This, therefore, means that Kenyan manufacturing firms have the capacity to increase their manufacturing outputs by 57.46% without having to increase the level of inputs or to even alter their technologies of production in any way. This could also be interpreted as manufacturing enterprises in Kenya operating at a level 57.46% lower than their optimal level of technical efficiency. Given that this sector is considered to be a priority sector in the country, this level provides a lot of room for improvement. As the governments of the day keep prioritizing this sector in line with the development blueprints, Kenya's manufacturing sector, by the year 2030, will propel the country into the status of middle income. To start, the coefficients for the inputs in the production frontier are all positive and statistically significant.

The study's second specific goal was also addressed and it was discovered that an enterprise's age and degree of experience of a firm's top managerial staff measured by the number of years that the top executive has spent working in the industry in which the firm operates, have a positive and statistically significant relationship with technical efficiency. This meant that in the Kenyan

context, the older a firm is, the higher the probability that it will be operating at a degree of technical efficiency that is much higher compared to its younger counterparts. The same goes for firms with the top managers having more years of experience working in the sector in which their respective firms operate. Therefore, these two factors are important in establishing the degree of technical efficiency of Kenyan manufacturing enterprises.

As for the size of the enterprises, the study found that small enterprises have negative and statistically significant relationship with technical efficiency. This is to mean that in Kenya, it is difficult for a small firm to be technically efficient. The medium sized firms have a relationship with technical efficiency that is negative as well, but this relationship is statistically insignificant. Finally, large firms in Kenya have a positive and statistically significant relationship with technical efficiency. Signifying that large Kenyan manufacturing enterprises possess higher levels of technical efficiency than small and medium-sized manufacturing firms. As a result, the size of a firm can be said to be a significant determinant of its degree of technical efficiency.

The research revealed that the relationship between technical efficiency and an enterprise's exporting status is positive but statistically insignificant. Meaning that even though a manufacturing firm in Kenya that exports its products is at a level of technical efficiency that is higher than a firm that does not export its products directly or indirectly, this difference cannot be attributed to the exporting status of the firm, but to other underlying factors in the production process. However, more research can be conducted to determine whether a firm’s size has any relationship with whether the firm exports globally or within Africa, and what other factors do firms that export their products have in common. This will be useful to determine the areas where Kenyan manufacturing firms especially, infant firms, require assistance from the government or the private sector so as to begin worldwide distribution.

Whether a firm undertakes research and development activities in its production or not, has a positive but statistically insignificant relationship with technical efficiency. Since (Barasa et al., 2018) and (Kalaycı & Pamukçu, 2014) discovered that for R&D to positively influence a firm's technical efficiency, the firm had to also incorporate technological innovation, we can conclude that most firms in Kenya have taken up more innovative technology in their production. (Kim et al., 2005) The degree of technical efficiency for Korean firms in the iron and steel industry was investigated, and it was discovered that the decision of a firm to adopt new equipment and new

technology in their production was one of the sources of increased technical efficiency for these firms. More research on the link between technological innovation, R&D, and technical efficiency could be conducted by future researchers to determine the link that exists, especially for Kenyan manufacturing firms.

According to the study, if a manufacturing enterprise in Kenya is owned by a foreign entity, it will have a negative and statistically insignificant relationship with technical efficiency. This means that whether the firm owner is a domestic entity or a foreign entity is not an important or a fundamental factor that influences the technical efficiency level for a manufacturing firm in Kenya. The issue of ownership can also be looked into further by including factors like technological innovations adapted by the firms from abroad to be able to provide a conclusive outcome on whether the ownership of a firm truly affects its level of technical efficiency. Furthermore, the study demonstrates that the location of manufacturing firms in Kenya influences both their technical efficiency level and the industry in which the firms operate. More research is needed to determine the effect of agglomeration on the technical efficiency level of Kenyan manufacturing firms, as well as which regions in Kenya benefit from agglomeration.

### 5.3 Conclusion

The decline in the performance of Kenya's manufacturing sector is of concern to the Kenyan government together with its local and international stakeholders. The importance of this sector is rooted in the need for structural change which will propel the country toward economic development. Thus, an examination of the degree of technical efficiency levels for manufacturing firms in Kenya is timely as it shows that the manufacturing firms in Kenya operate at 57.46% below their maximum potential level of output.

In developing countries, the majority of the studies undertaken therein have shown that manufacturing is indeed a key economic driver to transforming productivity to higher levels. (J. Page, 2013) argues that industrialization brings about structural change without which, developing countries cannot be able to sustain growth. In Kenya, the manufacturing sector still faces some challenges which include; inadequate infrastructure, poor level of capability and skills within the manufacturing sector, poor quality of inputs, high cost of operation of the firms, and low market access. Above this, it can be seen that the main obstacles faced by manufacturing firms in Kenya are the underutilization of their inputs or inefficiency in their allocation of resources.

From the study, it has been observed that large-sized firms, that is, those with 100 or more employees are more inclined to have a level of technical efficiency that is higher than that of small and medium-sized firms. Since it takes several years for a firm to become large, the age of a firm also affects its technical efficiency. What this means is that the more years an enterprise has been in business, the more technically efficient it is. The study also reveals that the more years of experience the top manager has in the industry in which the firm operates, the more technically efficient the firm will be. Furthermore, a firm owned by a foreign entity is less technically efficient than a firm owned by a domestic entity in Kenya. In addition, a firm that exports its products is more technically efficient than a firm that does not export its products, and a manufacturing firm that participates in research and development activities has also been seen to possess a level of technical efficiency that is higher than that of a firm that does not undertake such activities in Kenya. Manufacturing firms in Kiambu County have also been estimated to operate at a level of technical efficiency that is higher than that of the manufacturing firms in Mombasa, Nakuru, and Nairobi. Finally, the firms in the chemical, pharmaceutical, and plastics industries operate at higher degrees of technical efficiency as compared to the other manufacturing enterprises in industries like the food, and textiles and garments industries.

### 5.4 Recommendations and Policy Implications

The results from the study showed that the coefficients for a firm's age, the amount of experience the top manager possesses working in the industry n which the firm operates, and the firm's size are statistically significant and are positively related to the degree of technical efficiency of the enterprises. As a result, it can be deduced that these factors play a dominant role in exerting influence on the Kenyan manufacturing firms' degree of technical efficiency. The government of Kenya could take this to mean that they are to focus on providing an environment that is conducive for a firm to grow from a small to a large firm. This can be seen from the study, where, the firms that are large in size operate at a level of technical efficiency that is higher than that of the small sized firms. The government should also encourage training within the manufacturing firms to increase the level of expertise not only for the top managers but for all the staff in manufacturing firms since the study has proven that the more experienced the top manager is, the more technically efficient the manufacturing firm is.

More firms should be encouraged to undertake research and development activities, which improve the processes of production and may even lead to lower production costs to increase their level of technical efficiency. Since the undertaking of these activities may be expensive, the government could come in and subsidize these costs by encouraging the collaboration between learning institutions that undertake research and manufacturing institutions. In the study, manufacturing firms based in Kiambu County operate at a level of technical efficiency that is higher than that of manufacturing firms that are located in big towns or big cities like Nakuru, Mombasa, and Nairobi. This may be attributed to low labour costs and reduced competition among industries for raw materials. The government could support the industries in big towns by encouraging them to take operations to smaller towns to reduce their costs of production and also decrease the level of unemployment in these areas. It can do this by improving the infrastructure in smaller towns to make them more suitable to host these manufacturing firms.

### 5.5 Future Research Areas.

The study estimated the level of technical efficiency of manufacturing firms in Kenya and the factors that influence this level of technical efficiency. However, more factors could be examined to find the effect they have on manufacturing firms in Kenya. They include, whether or not a firm holds employee training, whether a firm takes up technological innovations from abroad, and the gender of the top manager. The study could also be extended to other sectors like the agricultural and service sectors which are quite large within the Kenyan economy. The status of a firm, whether formal or informal has also been shown to have an effect on technical efficiency by studies like (Bekele & Belay, 2007) who showed the importance of having books of accounts on technical efficiency.

(Kim et al., 2005) Investigated the level of technical efficiency of Korean iron and steel manufacturing enterprises and discovered a number of additional factors that influenced the firms' technical efficiency. That is, the privatization of government-owned firms increases their degree of technical efficiency, and a firm's decision to incorporate new equipment and new technology in production also increases its level of technical efficiency. Both of these factors are fundamental factors which should be studied and considered by researchers examining the technical efficiency of manufacturing enterprises in Kenya more broadly.

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