



**HAWASSA UNIVERSITY COLLEGE OF BUSINESS AND
ECONOMICS**

**ACCESING TECHNICAL EFFICIENCY AND PRODUCTIVITY GROWTH
OF MEDIUM AND LARGE SCALE MANUFACTURING INDUSTRIES IN
ETHIOPIA**

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OF MEDIUM AND LARGE-SCALE MANUFACTURING INDUSTRIES IN
ETHIOPIA**

**A THESIS PRESENTED TO HAWASSA UNIVERSITY DEPARTMENT OF
ACCOUNTING AND FINANCE**

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We the undersigned, members of the Board of Examiners of the final open defences by Merertu Bekele, have read and evaluate the thesis entitled “**Measuring technical efficiency and productivity growth of medium and large scale manufacturing industries in Ethiopia**”, and examined the candidate. This is therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the award of Master of Science (Msc) in accounting and finance

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ACRONYMS

BCC- Banker-charnes-cooper

CCR- Charnes-cooper-rhodes

CRS- Constant returns to scale

DEA- Data envelopment analysis

DMU- Decision making unit

GDP- Growth domestic product

LDC- List developed countries

MPI- Malmquist productivity index

MVA- Manufacturing value added

PECH- Pure technical efficiency change

PTE- Pure technical efficiency

SE- Scale efficiency

SECH- Scale efficiency change

TE- Technical efficiency

TECH- Technical efficiency change

TECHCH- Technological change

TFP- Total factor productivity

TPCH- Total productivity change

TTE- Total technical efficiency

VRS- Variable return to scale

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Abstract

The main objective of the study is to measure the technical efficiency and productivity of large and medium manufacturing industries. To compute efficiency score the study employed Constant Return to scale and Variable returning to scale using a dataset ranging from 2016 to 2020 of 44 sub industries out of 79 to industries. A purposive sampling technique is used identify and sample industries with full dataset on all input and output variables. Additionally, a Malmquist productive index is performed examine total productivity growth. To do this the study used a panel data of 15 major groups of industries with data ranging from 2007 to 2020. Secondary data was the only source and obtained from Ethiopian Statistical Service. To measure technical efficiency score two models were use: Constant Return to scale and Variable return to scale models. Based on constant return to scale model, on average, the efficiency value of the sample industries was 25.92% from the year 2016 to 2020. This reveals on average about 74.18% of inputs were inappropriately utilized. Whereas the average technical score when variable return to score model assumed was 28.76%. In addition Malmquist index result shows the sector under study had showed productivity progress by 5.7% over the study periods. This finding will have implication for policy makers and industry managers in order to be efficient.

Keywords: Efficiency, Pure Technical Efficiency, Scale Efficiency, Productivity, Manufacturing, Ethiopia

CHAPTER ONE

INTRODUCTION

1.1. Background of the study

Manufacturing sector plays curtail roles in production growth and job creation. It is the most important engine of long term growth and development both in developed and developing countries. However, Production fell by 61.8 percent in 2020 as a result of the pandemic, which had a greater impact on the manufacturing sector than it did during the global financial crisis of 2007 to 2009. Between 2019 and 2020, the manufacturing value added (MVA) as a percentage of the world GDP decreased from 160.6 to 16.0%. In comparison to 2019's 8.7 percent growth, manufacturing in least developed countries had 1. 9 percent increase in value added in 2020. Far too slowly to meet the goal of doubling that share by 2030, the manufacturing valued added share of these countries' total GDP increased from 10.1% in 2010 to 12.8% in 2020. Compared to \$4,296 in Europe and Northern America, the per capita MVA in LDCs was only \$136 in 2020 (UNSDG report 2021)

Ethiopia is among the least developed nations where agriculture makes up the largest portion of the economy. In 2022, the share of agriculture in Ethiopia's gross domestic product was 37.64 percent, industry contributed approximately 22.72 percent and the services sector contributed about 36.56 percent. The first Ethiopian Gross and Transformation Plan (2011–2015) also showed similar results, with the service sector trailing behind agriculture as the nation's primary source of GDP. According to United Nations report (2022), the manufacturing sector grew by 4% in 2022, the agricultural sector by 66%, and the service sector by 10%. However, the manufacturing sector makes up very little of the economy; instead, the agricultural and service sectors are what matter most.

The majority of developing nations, particularly those in Sub-Saharan Africa, have low manufacturing sector GDP contributions. For example, Djibouti's manufacturing sector contributes 17 percent of GDP, while Kenya's

is only 16 percent (Tadla and Kassa, 2015). Ethiopia's gross domestic product was made up of 37.64 percent agriculture, approximately 22.72 percent industry, and approximately 36.56 percent services sector in 2022. Manufacturing is part of industry and contributed about 4.24% . Technical efficiency is the ability of a firm to produce as much output as possible with a specified level of inputs, given the existing technology. It takes into account physical production relationships. It can also be as a situation wherein it is impossible, with current technical knowledge, to raise output from given inputs or, alternatively, to produce a given output by using less of one input without using more of another input (Farrell, 1957)

The prior studies on productivity focused on input productivity such as labor or capital as a measure of input efficiency in manufacturing sector (Shiferaw& Söderbom, 2018, Erena et al, 2021). .An increase in the level of productivity reflects an increase in the efficiency of inputs. Hence, the same level of inputs can produce higher output level, which means that cost of production reduces. In other words, it reflects an improvement in the quality of inputs. Technological advancement is closely related to capital intensity. Accordingly, in capital- intensive firms, productivity may be higher (Diao et al. 2017).

Most of the large and medium manufacturing establishments are located in Addis Ababa and rounding Addis Ababa. The sector is dominated by food products and beverages products which made up about 30% of the total industries (ESS, 2021). The sector is highly growing in terms of number of establishments and number of employees and production output. For Example in 2020, large and medium manufacturing industries registered value added more than 75billion ETB and number of employees reached about 400,000 permanent employees. Moreover, the sector constitutes 79 industries large and medium firms. Despite these facts, the sector is characterized by inefficient in productivity, less innovation practice and less competent in the global south market.

The need for the manufacturing sector to be efficient in order to lead the economy share and improve product quality while maintaining constant input/output ratios makes the study on the sources of productivity growth in the industry seem crucial. To be efficient means to be able to achieve goals by increasing output from the available input without sacrificing quality. Government officials, public bodies, and policy makers need to pay close

attention to this very certain area. Thus, this research may offer some insight into the factors influencing the manufacturing sector's productivity growth.

1.2 Statement of the Problem

The government is currently paying more attention to the manufacturing sector than it has in the past. It makes a major economic contribution and is crucial to the creation of jobs in both developed and developing nations. Ethiopia and other least developed nations relied heavily on agriculture. Agriculture is the main industry and is thought to be a possible source of jobs (Abegaz 2013). Among low-income nations, Ethiopia's manufacturing sector is arguably the most regressive and contributes the least to GDP. Despite this argument, there have been evidences that sector has experienced rapid expansion in terms of the number of firms, sales, and employment. However, the sector is currently mainly facing low-value and low-technology products, and weak inter-sectorial and intra-sectorial linkages. The sector's export orientation has been low and stagnant (Oqubay, 2019).

The contribution of output and employment from manufacturing sector is continuously increasing as observed in the first Ethiopian growth and transportation plan over 2011 to 2015 that is 10.7% while agriculture increased by 6.6%. This shows that the sector has been growing rapidly. However, the increase in number does not provide grantee to the manufacturing sector dominate the economy but the sectors able to be efficient technically and technologically. A larger company may be inefficient while's medium company efficient. Accordingly, an efficiency and technological progress in manufacturing sector need to be measured to enhance sustainability of production growth (Indris and Rahmah, 2006).

A number of prior studies have been done in manufacturing sector investigating the productivity of the sector. African Growth recently is characterized by increasing productivity in agriculture, a declining share of the labor force employed in agriculture and declining productivity in modern sectors such as manufacturing Diao et al. (2021). Abegaz (2013) justified that the sector is characterized by inefficiencies and low productivity. Partial reasons for the lower productivity and efficiency could be use of old techniques (lack of new technologies),

relative smallness in size, lack of competition (not being able to involve in exports) and also lack of research and development activities. Furthermore Erena et al. (2021) argue that large and medium manufacturing industries on average are inefficient and a significant amount input resources have been wasted every year. There is also a significant variation technical efficiency score among the industries suggesting a significant potential for improving efficiency in the sector. Hailu & Tanaka (2015).

Efficiency is actually a big issue in Ethiopia. Capacity utilization has long been an issue in the nation's manufacturing sector, and there are reasons to believe that many businesses require more capital to be an efficient. Similarly, Pickett (2015) highlighted Ethiopian manufacturing sector generally lacks effective and efficient utilization of resources. The sector is mostly labor-intensive rather than capital-intensive because it has a large labor force but very little capital. Either labor- or capital-intensiveness does not always translate into efficiency or inefficiency. Nonetheless, an efficient frontier might result from being able to increase production units (output) while maintaining constant input or decrease input while maintaining constant output.

An increase in productivity could result from improving productivity-based catching up capability. In particular, utilizing human capital in the labor market and implementing new technologies in an efficient manner. Conversely, if the best possible outcome from a technological shift could be obtained, moving from labor intensive to capital intensive would boost productivity. The high cost of physical assets makes it inefficient to not fully benefit from technological advancements. The manufacturing sector in Ethiopia is primarily labor-based. The industry would be efficient if it employed trained, seasoned, and educated labor. Put another way, the industry won't be effective and competent on a global scale if it keeps using creative labor without implementing new technology. Besides this, there are limited number of empirical findings addressing the productivity growth in large and medium manufacturing industries (Erena et al. 2021; Tekleselassie et. al., 2018, Hailu& Tanaka,2015). These studies focused on less number of sample size or specific industries and used relatively old dataset. Thus, the present used larger sample industries and up to date dataset. study The paper will answer the following questions:

1. What are the efficiency scores of the manufacturing sector?

2. If there is a technical inefficiency, what is the source of inefficiency?
3. Is there any change in total factor productivity in manufacturing sector during the periods under consideration?

1.3. Objective of the study

1.3.1. General Objective

The main objective of the study is to assess technical efficiency and productivity growth in large and medium manufacturing industries using data Envelopment Analysis

1.3.2 Specific Objectives

To achieve the general objective, the targeted specific objectives are:

- ❖ To measure the technical efficiency scores of the sector.
- ❖ To identify the source of technical inefficiency
- ❖ To analyze the trend of productivity over time

1.4. Significance of the Study

The findings of the study have following implications. First, the findings will give an insightful for policy makers, government units, industry practitioners and company managers in that how well the sector is doing in utilizing scarce resources to optimize its productivity. Second, the study would invite further research projects as the area is so fertile for research projects particularly, masters and PhD students might find the area interesting to write a thesis or dissertation. Finally, the study has theoretical contribution in extending productivity literature with a new findings and insight

1.5 Scope of the Study

The study conceptually confined to technical efficiency, technological change and productivity growth of medium and large manufacturing companies operating in Ethiopia for the period 2007 to 2020. I made the analysis in two ways (1) to measure technical efficiency, 44 sub industries were taken; (2) A Panel dataset of 15 major industrial groups with 14 years data (2007 to 2020) has been used to analyze Malmquist Productivity index. In the second

analysis all sub industries were assumed.

1.6 Limitation of the study

The present study recognized the following limitations. First the model DEAP analysis is a non-parametric model which does not examine the relationship between variables and how variables are granger cause each other. Second the study identified that there is a large variation in technical efficiency score among the sample industries. However, this study has not addressed the cause of the variation that would be appeared because of industries size, age and capital or labor intensive. Thirds, as there is no update dataset of the target industries, the current study used the available data up to 2020. No survey has been conducted since the pandemic outbreak. Hence, My findings might not be generalized and show the current status of the sector in terms of productivity and technical efficiency. Finally, our sample size is relatively small because several industries have missing data that could not fit the DEA. Therefore, the sample industries with full dataset over the study periods.

1.7 Organization of the Paper

The paper is organized into three chapters: chapter one presents introduction involving research gap, objective, scope and significance. Chapter two describes theoretical vies and empirical findings related to productivity and data envelopment analysis. Chapter three discusses methodology of the study involving population, sample, data source, method of data analysis, and model specification. Chapter four presents the results and discuss and chapter five provides final remark and the way forward for potential stakeholders.

CHAPTER TWO

RELATED LITERATURE REVIEW

The link between the relative technical efficiency and technological change to productivity growth

Productivity growth permits a company to increase profit and market share at the micro-level, and it assists a Country to create jobs, counter act inflation, and force the necessary industrial restructuring at the macro-level (J.D. Lee & Heshmati, 2009). There is widespread agreement among academic researchers in the Field of growth theory, policymakers, and businessmen that productivity raise is essential for continued Economic growth (J.D. Lee & Heshmati, 2009). In one of the original contributions to economic Growth theory, the investigations of economic growth by Abramovitz (1956), Denison (1962), And Kendrick (1956), productivity/efficiency was considered transcendent for clarifying a note worth Portion of growth, as Griliches(1998) indicated. In these studies, the authors wanted to review the Behavior of growth rates of physical and labor capital as well as the growth rates of per capita production within The USA . From their conclusions, they asserted that much of the growth was because of productivity or, Agreeing to Abramovitz (1956), the measure of our ignorance. Having confirmed the significance of Productivity for economic growth, Denison (1962) contended that one of the explanations for its Acceleration rested in economies of scale, but this might not be directly influenced.

Among the contributions of Solow (1956) and Swan (1956), who introduced productivity into an economic growth model, where it had been called technical progress. The growth model was supported by the analysis of a neoclassical production function, which assumed constant returns to scale and decreasing returns on inputs. Solow (1956) stated technical progress was an increasing factor of scale by which production was multiplied. Meanwhile, Swan (1956) said technical progress was initially neutral but increased its responsibility for rises in output that were not caused by rises in capital or labor and indirectly increased production by increasing the contribution of capital. In contrast to those models, endogenous model appeared within which technical progress would be internal to the model of economic growth. Among these

studies are Lucas (1988), Romer (1986, 1990), who were also known for their attention to increasing incomes at scale and the consideration of models in flawed equilibrium, assuming equilibrium in monopolistic competition and the inclusion of human capital stock in the production function. Though, considering TFP, technical progress, or technological change, there is also the model of Mankiw et al. (1992) which wanted to defend Solow's contributions to economic growth by finding solutions to some of the critiques indicated in the original model. Thus, it was treated as an augmented Solow model with human capital, and to the authors, that alternation better fit the explanation of the growth of nations. In a similar vein, the mainstream approaches to economies of innovation by Acemoglu and Zilibotti (2001) pointed out that many technologies used by the least developed countries (LDCs) are developed in the advanced economies and are designed to make optimum use of the skills of these richer countries' workforces. Differences in the supply of skills create a mismatch between the requirements of these technologies and the skills of LDC workers and lead to low productivity in the LDCs. Even when all countries have equal access to new technologies, this skill-technology disparity can lead to sizable differences in TFP and production per worker. For example, the evolutionary approach of Nelson and Winter (1973) to the economics of innovation indicated diffusion processes for new technologies and the existence of significant differences among firms in terms of profitability, the technology used, lead to differences in productivity and growth. Similarly, Geroski et al. (1993) in their studies on the profitability of 721 innovating manufacturing firms in the UK, found the number of innovations achieved by manufacturing firms had a positive impact on operating profit. They also indicated innovative firms were more profitable than non-innovative firms in general, although the effect of specific innovation types on firm profit margin was only modest in size.

The term economic efficiency refers to the use of resources to maximize the production of goods and services. In absolute terms, the situation can be called economically efficient if: (1) no one can be made better-off without making someone else worse-off, (2) no additional output can be obtained without increasing the amount of input, and (3) production proceeds at the lowest possible per-unit cost (Sullivan & Sheffrin, 2007).

Efficiency can be categorized into technical, allocative, or the combination of the two (i.e. total economic

efficiency) based on the scope of efficiency targeted (Bhat et al., 2001). Technical efficiency means producing maximum output with given inputs, or equivalently, using minimum inputs to produce a given output (Farrell, 1957). Farrell (1957) considered a production function for a fully efficient firm and analyzed technical efficiency for a production firm as the ratio of the output of any given firm to that of a fully efficient firm. Allocative efficiency deals with the minimizing of the cost of production with a proper combination of inputs for a given level of output and a set of input prices, assuming that the entity examined is working at full technical efficiency. These technical and allocative efficiencies can be combined as a measure of economic efficiency.

TFP can effectively contribute to output growth by improvements in technology and efficiency, as these are two determinants of TFP, under constant returns to scale. If returns to scale are variable, TFP growth can be generated by technical change, efficiency improvement, and scale effects. This also reinforces the potential role played by technical efficiency in determining productivity and therefore the need for the relation of assumptions to accommodate inefficiency and efficiency variations. Technical efficiency reflects firm-specific technical knowledge and effort (Page, 1980), the will, skills, and determination of employees and management (Aigner et al., 1977; L.-F Lee & Tyler, 1978), and the effects of work stoppages, managerialTo explore sources of productivity growth in the presence of inefficiencies, it is essential to appropriately model production technology and inefficiencies among economic agents. Data envelopment analysis (DEA) has been extensively used to analyze productivity growth and inefficiencies. Data envelopment analysis represents a method of analysis that can serve as an aid in identifying best practice performance in the utilization of resources amongst firms of a similar category. Such identification can highlight where the most significant benefits can be made from efficiency improvements and assist organizations to realize their maximum potential. Measurement tools such as DEA are useful in situations where government bodies operate in markets, which are distorted by prices closely controlled by the government, subsidies, and a lack of contestability. In these cases, the same old market indicators of performance such as profitability and rates of return cannot be used to measure an organization's economic performance accurately. Despite this, governments and the public at large are still worried that these organizations operate efficiently. In these situations, DEA provides comparative

monitoring that identifies variations and hence provides encouragement and direction for the improvement of the performance (Abbott & Doucouliagos,2003) Most of the prior literature on productivity focused on input productivity like labor or capital as a measure of input efficiency. A rise in the level of productivity reflects a rise in the efficiency of inputs. Hence, the same level of inputs can produce higher output levels, which suggests a reduction in the cost of production. In other words, it reflects betterment in the input qualities. A study conducted by Bhatia([1990](#)) on misleading growth rates in the manufacturing sector argued that unstable socio-demographic changes and lower levels of technology are causing low productivity in India as compared to the United Kingdom and the United States. In his study of the manufacturing sector in India using data for 21 years (from 1965 to 1985), it was pointed out that factor efficiency was influenced by the factor of production, socio-demographic, socio-politics, development and management of the human resource, workplace, and working condition where a higher capital-labor intensity ratio is associated with a higher level of technology.

2.2. Manufacturing sector of Ethiopia

Ethiopia began its first series of economic reform programs in 1992. The reform programs are aimed at reorienting the economy from a command to a market economy, rationalizing the role of the state, and creating legal, institutional, and policy environments to enhance private-sector investment. Different sectoral policies, strategies, and plans were developed and implemented in an effort to make the manufacturing industry play a great role in the economy. As a result of the economic reforms and priorities given to the sector, its contribution to the economy has increased from 11.4% in 2003/2004 to 13.4% in 2010/11 and within the industry, the construction and manufacturing sub-sectors have registered a high growth rate of 12.8% and 12.1% respectively (MoFED, 2011). The fact that the contribution of the manufacturing sector to GDP is minimal exhibits the infant stage of manufacturing activities or industrialization in Ethiopia. This low contribution of the manufacturing sector to the GDP is the common feature of most developing countries that are especially found in Sub-Saharan African countries. The share of the manufacturing value added (MVA) is one of the indicators which pave the way to assess the sector's performance against other economies.

The Ethiopian manufacturing sector is dominated by food products and beverages and non-metallic mineral manufacturing sub-sectors. In 2017, the former made up about 26% of the establishments in the manufacturing sector (CSA, 2018). The relatively high number of food products and beverage manufacturing industries is mainly explained by the high local input content and the availability of large local markets for food products and beverages (Befekadu & Berhanu, 2000). In 2017, grain mill products manufacturing firms (GMPMF) contributed about 35% of the manufacturing of food products and beverages industrial group (CSA, 2018). Industries such as metal processing, electrical and electronics, chemical, and other engineering industries, which help build technical capabilities and dynamism, have not yet been developed. Most manufacturing exports are focused on agriculture, including drinks, clothes, shoes, and semi-processed hides. On the other hand, most capital goods and manufactured consumer goods are imported into Ethiopia, which is also heavily reliant on the importation of fuel. On the policy facet, the government is committed to creating a favorable environment for attracting direct foreign investment and promoting domestic investment. A variety of foreign companies from China, India, Turkey, and Japan are presently competing in the country to leverage this opportunity. The preferential dutyfree trade access provided by Ethiopia to the United States of America and European Union markets also provides strategic opportunities (Hailu & Tanaka, 2015).

2.1. The Concept of Efficiency

In economics, the term economic efficiency refers to the use of resources so as to maximize the production of goods and service. In absolute terms, the situation can be called economically efficient if: (1) No one can be made better off without making someone else worse off, (2) No additional output can be obtained without increasing the amount of inputs, and (3) Production proceeds at the lowest possible per-unit cost (Sullivan and Sheffrin, 2007).

2.1.1. Categorization of Efficiency

Efficiency can be categorized into technical, allocative or into the combination of the two (i.e. total economic efficiency) based on scope of efficiency targeted (see Farrell, 1957; Bhat *et al*,2001)

Technical Efficiency means producing maximum output with given inputs; or equivalently, using minimum inputs to produce a given output (Farrell, 1957).

Allocative efficiency deals with the minimizing of cost of production with proper combination of inputs for a given level of outputs and a set of input prices, assuming that the entity examined is working with the full technical efficiency.

Total Economic Efficiency represents a combination of technical and allocative efficiency (Coelli, 1996).

An entity will only be economically efficient (cost efficient) if it is both technically and allocative efficient. That means, cost (total economic) efficiency is the product of the technical and allocative efficiency scores (Bhat *et al.*, 2001).

Firm Productivity Measurement Productivity

The efficiency, with which inputs are converted into outputs, is a fundamental concept in economic analysis. Productivity growth is the basis for improvements in real income and welfare. The measures of levels and growth of productivity, therefore, represent important economic performance indicators. The economic theory of productivity measurement dates back to the works of Jan Tinbergen (1942, as cited in OECD Productivity Manual, 2001) and Robert Solow (1957). They developed productivity measures in the framework of a production function relating to the analysis of economic growth. The literature on the subject has made a remarkable progress since then and the concern of productivity has become pervasive in today's globalized world

According to the OECD (2001), the objectives of productivity measurement can be summaries as follows:

Technology: A frequently stated objective of measuring productivity growth is to trace technical change.

Efficiency gains: A firm's internal efficiency is an important factor for its economic viability – efficiency both in terms of the use of inputs, given technology (i.e. technical efficiency), and in combining its inputs, given technology and market prices (i.e. allocative or price efficiency). Technical efficiency refers to the “ability of firms to maximize output from a given combination of inputs and technology”, i.e. the effectiveness with which resources are being used (Hill and Kalirajan, 1993). It occurs when a firm makes the best use of its inputs, given

technology (i.e. operating on the production frontier). Allocative efficiency, on the other hand, occurs when a firm uses its inputs in ‘optimal’ proportion, given technology and prices (i.e. operating at the optimal point on the production frontier or using optimal levels of inputs).

Benchmarking production processes: Productivity measures can be used to compare a given production process across firms in the same industry (firms using similar inputs to produce similar output). Firms can then use this result to know their position in terms of productivity in the industry and work accordingly. Living standards: Productivity matters because it is the main determinant of national living standards.

Measures of Productivity

The literature provides several productivity measures. The choice between these measures depends on the purpose of the measurement and the availability of data. Productivity measures can broadly be classified as single factor productivity measures and multi-factor productivity measures (also known as total factor productivity). The former reflect units of output produced per unit of a given input, the later relates to a measure of output to multiple inputs (OECD, 2001; Schreyer and Pilat, 2002). This distinction applies to both macro level and industry or firm level productivity analysis. Another distinction of particular relevance at the industry or firm level is between productivity measures that relate gross output to one or several inputs and those, which use a value-added concept to capture movements of output. The single factor productivity levels are likely to be influenced by the intensity of use of the omitted factor inputs. It is possible that two producers having the same production technology may have different labor productivity levels if one happens to use capital much more intensively than the other due, for instance, to differences in factor prices (Syverson, 2011). Cognizant of this, researchers often use a productivity measure that is invariant to the intensity of use of observable factor inputs, namely total factor productivity (TFP). The idea is that variations in TFP reflect shifts in the isoquants of a production function indicating that producers with higher TFP will produce greater amounts of output with the same set of observable inputs than those with lower TFP (Syverson, 2011). Unlike in the case of single factor productivity, TFP is less likely to be affected by difference in factor prices because it induces movements along isoquants rather than shifts in isoquants.

2.1.1. Non-parametric Approach

Non-parametric approach is based on the concept of efficiency similar to one in the parametric approach but differs from it since this approach does not require any pre-specified function. It takes the data of the actual operations of the firms under study and frontier is formed as the piecewise linear combination of the “most efficient observations.” Thus, efficiency so determined is relative to the “observed best”, rather than an absolute value (Gupta *et al* 2003).

It is also mathematical approach known under the name of DEA method (Data Envelopment Analysis) consists in estimating the frontier by using non parametric mathematical linear programming. It offers an analysis based on the relative evaluation of the efficiency in an input/output multiple situations, by taking into account each firm and measuring its relative efficiency to an envelopment surface made up with the best firms. However, this method doesn't allow for noise treatments. The non parametric method was usually used by making the assumption of constant return to scale (CRS). But recently, the assumption of variable return to scale (VRS) was used in specifications because this hypothesis is more relevant with the environment of imperfect competition in which firms operate (Kablan, 2007).

2.1.2. Parametric Approach

The parametric approach is based on the fundamental relationship between the parameter under study and various observed independent variables. It is an econometric application in which one specifies some clear form of the production, cost, or profit function to symbolize the benchmark technology for efficiency measurement. The soundness of the derived measures of efficiency, critically depend on the suitability of the functional specification, consequently requires a specific pre-specified function form of the production or cost function (Gupta *et al.*, 2003).

The econometric approach consists of an econometric estimate of the preeminent practice frontier by its arrangement in a Cobb-Douglas, cost or production function. The econometric method can be deterministic. In

this case, every divergence from the frontier is attributed to inefficiency. It can also be stochastic; it is then possible to detach random errors from the production unit inefficiency. The stochastic frontier method has two principal advantages compared to non-parametric DEA method. First, it allows separating random error from the production unit inefficiency and takes into account the existence of exogenous shocks. At this point, the error term is divided into two components: an inefficiency component and a random one (which is composed of the error measurement and the exogenous shocks). Second, the stochastic frontier analysis is less sensitive to silly values. The question that we are addressing by using the stochastic frontier analysis is what is the optimal combination of inputs? That makes it possible to produce an optimal combination of outputs while minimizing production costs (Kablan, 2007).

2.2. Technical Efficiency, Pure Technical and Scale efficiency

For detail understanding the concepts of technical, pure technical and scale efficiencies it requires some elaborations. Kumar and Gulati (2008) clearly stated that a measure of technical efficiency under the CRS assumption is known as a measure of overall technical efficiency (OTE). The OTE measure helps to determine inefficiency due to the input/output mix and the size of operations. In DEA methodology, OTE measure has been decomposed into two mutually exclusive and non-additive components: pure technical efficiency (PTE) and scale efficiency (SE). Like the OTE measure, the PTE measure also indicates the underutilization of inputs. However, unlike the OTE measure, the PTE measure is free of scale effects. This decomposition allows an insight into the source of inefficiencies. The PTE measure is obtained by estimating the efficient frontier under the assumption of variable returns-to-scale. It is a measure of technical efficiency without scale efficiency and purely reflects the managerial performance to organize the inputs in the production process. Thus, PTE measure has been used as an index to capture managerial performance. The ratio of OTE to PTE provides SE measure.

The measure of SE on the other hand, provides the ability of the management to choose the optimum size of resources, i.e., to decide on the firm's size. In other words, it shows selection of the scale of production that will attain the expected production level. Inappropriate size of a firm (too large or too small) may sometimes be a cause of technical inefficiency. This is referred as scale inefficiency and takes two forms: decreasing returns-to scale (DRS) and increasing returns-to-scale (IRS). DRS (also known as diseconomies of scale) implies that a firm

is too large to take full advantage of scale and has supra-optimum scale size. In contrast, a firm experiencing IRS (also known as economies of scale) is too small for its scale of operations and, thus, operates at sub-optimum scale size. A firm is scale efficient if it operates at constant returns-to-scale (Chansern, 2008).

2.2.1. Data Envelopment Analysis (DEA) Models

The Data Envelopment Analysis is initially developed by Charnes *et al.*, (1978) to evaluate the efficiency of public sector non-profit organisations (Molyneux *et al.*, 1996). Charnes, Cooper and Rhodes (1978) proposed the model that had an input orientation and assumed constant returns to scale (CRS). The alternative paper by Banker, Charnes and Cooper (1984) consider the sets of assumptions, which is a variable return to scale (VRS).

In the CCR model, it is proposed that the efficiency of any DMU can be obtained as the maximum of a ratio of weighted outputs to weighted inputs subject to the condition that similar ratios for every DMU are less than or equal to one. Using the fractional programming theory, the ratio optimization problem is transformed into an ordinary linear programming problem. To obtain the efficiency of all DMUs, it is necessary to solve a series of linear program, one for each DMU as the objective function.

Banker, Charnes, and Cooper (1984) introduced the BCC model in which the envelopment surface is variable returns to scale. The CCR model estimates the overall technical and scale efficiency of a DMU. However, the BCC model considers the possibility that the most productive scale size may not be attainable for a DMU which is operating at another scale size. It estimates the pure technical efficiency of a DMU at the given scale size of operation.

DEA identifies the most efficient units and indicates the inefficient units in which real efficiency improvement is possible. The amount of resources saving or services improvement that can be achieved by each inefficient unit to make them efficient is identified and can be used as indications for management action.

DEA produces a single score for each unit, which makes the comparison easy. Unlike ratios, it can accommodate multiple inputs and multiple outputs. These inputs and outputs can be in different units of measurement.

In contrast to regression methods, DEA focuses on individual observations and optimizes the performance measure of each DMU. A prior knowledge of weights or prices for inputs and outputs is not required in DEA; however, managerial judgment can be accommodated when desired.

Another DEA advantage that attracts analysts and management is its ability to identify the potential improvement for each inefficient DMU. For units enveloped by the frontier, the inefficient units, DEA compares the unit with a convex combination of DMUs located on the frontier. The frontier enables the analyst to indicate the sources and the level of inefficiency for each of its inputs and outputs (Charnes *et al.*, 1978).

The same features that make DEA a powerful tool can also create problems. The following limitations must be considered when choosing whether or not to use DEA (Bhat2001).

- a. Since DEA is an extreme point technique, noise (even symmetrical noise with zero mean) such as measurement error can cause significant problems.
- b. DEA is good at estimating “relative” efficiency of a DMU but it converges very slowly to “absolute” efficiency. In other words, it can tell you how well you are doing compared to your peers but not compared to a “theoretical maximum.”
- c. As efficiency scores in DEA are obtained after running a number of Linear Programming problems, it is not easy to explain intuitively the process of DEA for the case of more than two inputs and outputs to a non-technical audience. This cannot be a problem in current technology when different software can be easily applied to get efficiency score.

2.3. MALMQUIST PRODUCTIVITY INDEX

The Malmquist index evaluates the productivity changes over time. In the non-parametric framework, it is measured as the product of catch-up (recovery) and frontier-shift (innovation) terms, both coming from the DEA technologies. The catch-up term relates to the degree that a DMU attains for improving its efficiency, while the frontier-shift term reflects the change in the efficient frontiers surrounding the DMU between the two time periods (Cooper, *et al.*, 2004).

The Malmquist index can be decomposed to capture the two components, technological change and technical efficiency change. Technical efficiency can be further decomposed into a pure technical efficiency and a scale efficiency change components. The change in technical efficiency is described as the efficiency in reaching to the production limit and technological change described as the curve shift in productivity limit. Change in the total factor productivity is the product of the change in technical efficiency and technological change. If the value of Malmquist index or any of its components is less than 1, that denotes regress or deterioration in performance, whereas values greater than one denote improvements in the relevant performance (Fare *et al.*, 1994). On the other hand, the value being equal to one means there is no change in productivity or its components. The average growth rate in the specific component is the difference between the measured index and one.

CHAPTER THREE

3. RESEARCH METHODOLOGY

The study aims at measuring technical efficiency, technological progress and productivity growth in manufacturing sector from the period 2007 to 2020 using data envelopment analysis.

3.1 Description of the study Area

Manufacturing is one of the rapidly growing sectors in Ethiopia. According to Central, statistical Agency (2020)

report, there are more than 3,500 medium and small manufacturing companies operates in Ethiopia. About 40 percent of them found in Addis Ababa whereas, 23 percent found in Oromiya Regional State, 11 percent in Amhara and 9 percent in Tigray. Food products and beverages share highest 31 percent followed by non-metallic 18 percent. Textile industry share only 1.7 percent

3.2 Research Design

The research design is the conceptual framework by which the research is conducted; it also serves as the blueprint for the data collection, measurement, and analysis. To achieve the objective and research questions the study used descriptive research design because it is the best approach to describe the technical efficiency of the target industries (Creswell, 2009).

3.3 Research Approach

According to Creswell (2009), there are three approaches of research; those are qualitative, quantitative, and mixed approaches. A qualitative research approach is an approach used for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. The process of research involves emerging questions and procedures, data typically collected in the participant's setting, data analysis inductively building from particulars to general themes, and the researcher making interpretations of the meaning of the data. The final written report has a flexible structure. Those who engage in this form of inquiry support a way of looking at research that honors an inductive style, a focus on individual meaning, and the importance of rendering the complexity of a situation. In this approach, the researcher's intention is theory development, by analyzing the situation from particular to general activities. The current study employed quantitative research approach with descriptive design

3.4 Population, Sample and Sampling Techniques

According to CSA (2022) there are more than 3,500 medium and large manufacturing industries in Ethiopia with 79 sub industries and 15 major industries groups. In this study two groups of sample size were used. Frist, to compute annual technical efficiency of the industries both Constant Return to Scale and Variable Return to Scale, 44 sub industries purposely selected with 5 years data (2016 to 2020). Industries with missing variable were

excluded from this analysis. Second, in the case of Malmaquist index analysis, 15 major industrial groups were considered with 14 years dataset ranging from 20007 to 2020. This analysis is assumed to compute Total Productivity change over the specified time period. The list of sampled industries is provided in appendix section.

3.5 Type of Data

As there is no firm level data, the present study used industrial level panel data of large and medium manufacturing industries collected annually by Ethiopian Statistical Service for the period 2007–2020. No survey has been conducted since the pandemic outbreak, 2020 so that the recent dataset is up to 2020. The annual surveys conducted by ESS covers all manufacturing establishments that employ at least 10 workers and use electricity in production. Information regarding gross value of production, costs of materials, number of employees, total wages paid, energy expenditure, fixed capital, among other issues are largely covered in the surveys.

3.6 Method of Data Analysis

The study applied DEA based on the input orientated analysis i.e., reducing a set of input while keeping output constant. Alssaleh, (2012) stated that in firms where the focus is on technical efficiency, input-orientated could be an appropriate choice. To do this both the Charnes–Cooper–Rhodes (CCR) and Banker–Charnes–Cooper (BCC) models were used. In CCR model, I estimate overall technical efficiency of the sample industries. However, scale efficiency is determined from the ratio of overall and pure technical efficiencies. BCC model is run to fix on the source inefficiency score consisting of pure technical inefficiency or scale inefficiency. A DEAP version 2.1 software tool was used to measure the technical efficiency, technological progress and productivity growth.

3.7 Data Envelopment Analysis Model

Data envelopment analysis has been frequently used to measure the relative efficiency manufacturing companies. Measuring technical efficiency, technological progress and productivity growth requires selection of appropriate input and output variables. Thus, drawing on prior studies (Erena et al., 2021, Hailu & Tanaka, 2015) I select two input variables: *Total fixed asset (Capital) and number of employees (Labor)*, Similarly two output variables are assumed , *Value Added at national market price and Operating Surplus*.

Variable	Definition	Source
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Value added	Gross production minus production costs	ESS https://www.statsethiopia.gov.et
Operating Surplus	Sales minus – operating expenses	ESS
Capital	Total Fixed asset	ESS
Labor	Number of employess	ESS

Source: ESS Survey Report on Large and Medium manufacturing industries

3.5.1 Model Specification

Following empirical studies I adopt CCR and BCC models to estimate the relative efficiency and Malmquist productivity index in order to measure total factor productivity change.

$$\text{Efficiency} = \frac{\text{weighted output}}{\text{Weighted input}} \dots\dots\dots 1$$

3.5.2 CCR & BCC EFFICIENCY MODELS

In order to estimate efficiency scores and identify sources of inefficiency, the study will apply input-oriented DEA. First I adopt CCR model which assumes CRS according to the following equation (Charnes et al., 1978):

$$\min \theta - \varepsilon \left[\sum_{i=1}^m S_i^- - \sum_{r=1}^s S_r^+ \right] \dots\dots\dots 2$$

Subject to:

$$\sum_{j=1}^n \mu_j x_{ij} + S_i^- = \theta k x_{ik} \quad i = 1, \dots, m$$

$$\sum_{j=1}^n \mu_j y_{rj} - S_r^+ = y_r k \quad r = 1, \dots, s$$

The scalar variable θ is the proportional reduction which should be applied to all inputs of DMU, in order to make them efficient, and ε is non-Archimedean defined to be smaller than any positive real number, whereas S^- and S^+ are "Slack variables" and a standard Linear Programming terminology for additional variables added to the model

in order to convert inequality constraints to equality constraints. This terminology in DEA is also used when additional improvement is possible in specific inputs or outputs.

Coelli (1996) stated that the use of the CRS specification when some of the DMUs are not running at optimal scale will result in measures of technical efficiency which are mixed up with scale efficiency. To overcome this problem, Banker et al (1984) suggested their model known as the BCC model. It improved the CCR model by introducing a variable that represents the returns to scale. The BCC model allows a calculation of technical efficiency that is free from the scale efficiency effects. In the BCC model, the formulation is written as below (Banker et al. 1984)

$$\min \theta - \varepsilon \left[\sum_{i=1}^m S_i^- + \sum_{r=1}^s S_r^+ \right]$$

Subject to

$$\sum_{j=1}^n \mu_j x_{ij} + S_i^- = \theta k x_{ik} \quad i = 1, \dots, m$$

----- 3

$$\sum_{j=1}^n \mu_j y_{rj} - S_r^+ = y_r k \quad r = 1, \dots, s$$

$$\sum_{j=1}^n \mu_j = 1, j = 1, \dots, n$$

$$\mu_j, S^+, S^- \geq 0 \quad j = 1, \dots, n$$

A DMU is BCC-efficient if and only if $\theta^* = 1$ and all slacks are zero. The envelopment surface in BCC model is variable returns to scale and this is the result of the presence of the convexity constraint ($\sum_{j=1}^n \mu_j = 1$).

The Malmquist Model will be developed to combine inputs and outputs and then measure changes and productivity change between two data points over time, by calculating the ratio of distances of each data points relative to a common technology.

Fare *et al.* (1994) specify the Malmquist productivity change index as:

$$M_{t+1}(x_{t+1}, y_{t+1}, x_t, y_t) = \sqrt{\frac{Dt(x_{t+1}, y_{t+1})}{Dt(x_t, y_t)} \frac{Dt+1(x_{t+1}, y_{t+1})}{Dt+1(x_t, y_t)}} \quad 4$$

This decomposed into:

$$M_{t+1}(x_{t+1}, y_{t+1}, x_t, y_t) = \frac{Dt+1(x_{t+1}, y_{t+1})}{Dt(x_t, y_t)} \sqrt{\left[\frac{Dt(x_{t+1}, y_{t+1})}{Dt+1(x_{t+1}, y_{t+1})} * \frac{Dt(x_t, y_t)}{Dt+1(x_t, y_t)} \right]} \quad 5$$

Technical efficiency change (Tech)* Technological change (Techch)

CHAPTER FOUR RESULTS AND DISCUSSION

This section presents the detail discussion and analysis of the findings of the study. A dataset of large and medium manufacturing industries was obtained from Ethiopian Statistical Service to measure relative technical efficiency (TE), pure technical efficiency (PTE) and scale efficiency (SE). The same data were used to compute the total factor productivity (TFP) change during the study period.

4.1 Descriptive statistics

Descriptive statistics provides guarantee whether or not variation in data is large. Table 1 reports descriptive statistics (mean, standard deviation, minimum and maximum) for output and input variables of this study. The

mean value of Value Added (output1) is birr 3,111,122.99, the minimum value is birr 3,647 and the maximum value is birr 43,336,392. Whereas the mean of operating surplus (output 2) is birr 1,918,486.65, the minimum and maximum values are birr 1,033 and birr 25,216,097, respectively. The Large and Medium Manufacturing Industries on average had birr 3,961,964.20 capital (fixed asset value) during the observation period ranges from 2007 to 2020. The minimum and maximum values are birr 4,552 and birr 52,541,679, respectively. Labor (number of employees) (input 2) had birr 16164.31 mean value with 48 minimum and 90703 maximum.

Table 1: Descriptive Statistics for Input and Output Variables

Variable	Obs.	Min	Max	Mean	Std.Dev
Value added at Market price (Output)	210	3647	43336392	3111122.99	5712174.313
Operating Surplus (Output)	210	1033	25216097	1918486.65	3541976.614
Capital (Input)	210	4552	52541679	3961964.20	8909983.194
Labor (Input)	210	48	90703	16164.31	19194.262

Note: All values are in ('000') and in Ethiopian birr.

As can be seen in table 1, the values of standard deviation on all variables exceeds its corresponding mean value showing that there has been big variation among the industries over the observation years. One of the reasons of the variation could be size, age and technological differences.

4.2. RESULTS OF DATA ENVELOPMENT ANALYSIS (DEA) MODELS

This section discusses results obtained from DEA models: CCR model with the assumption of constant return to scale (CRS) and BCC model under the assumption of variable return to scale (VRS). Sarkis, (2000) argued that the use of the CCR and BCC models together helps to determine the overall technical and scale efficiencies of the firm and whether the data exhibits varying returns to scale. The study employed input oriented approach assuming that minimizing usage of input keeping output constant is more sound able than increasing output without reducing input usage. Because it can be assumed that manufacturing industries could potentially impact its input

than output. Alssaleh, (2012) stated that in firms where the focus is on technical efficiency, input-orientated could be an appropriate choice.

The productivity growth of the sector over the observation period (2007 - 2020) has been computed under Malmquist Productivity Index (MPI). The technical efficiency obtained from a CRS further decomposed into two components: Pure technical inefficiency and Scale inefficiency. Technical efficiency (TE) is calculated by a CCR model, whereas a BCC model calculates pure technical efficiency (PTE). If there is difference between the two efficiency values, there is scale inefficiency which is computed from the ratio of technical efficiency to pure technical efficiency (TE/PTE). If pure technical efficiency is greater than scale efficiency, then inefficiency is caused by scale inefficiency. If pure technical efficiency is greater than scale efficiency, then inefficiency is caused by scale inefficiency

CCR Model results

The CCR model measures the overall or technical efficiency under the assumption of constant return to scale. Constant return to scale assumes that a change in an input changes an output proportionately. Table 2 presents the overall efficiency of the sampled 44 sub – industries.

As can be observed in table 2, in 2016 three (3) sub industries (manufacture of tanks, reservoirs and containers of metal, manufacture of parts and accessories for motor vehicle and manufacture of Service activities related to printing) were relatively technically efficient while 41 sub industries were inefficient relatively to efficient peers. These industries have been relatively efficiently utilized their inputs in the year indicating that the management success in allocating and converting its input to output. In a contrast, the inefficient industries have been relatively inefficient in utilizing and converting their resources. Among the inefficient industries, manufacturer of preparation and spinning of textile fibers found to be the least inefficient industries with 0.054 efficiency value, showing the industry has misused 94.6% of its input in 2016. It could have produced the current level of the output if input variables were reduced by 94.6%. On average, the sector has registered 0.328 efficiency score in the year. It suggests that adopting the best practices the industries could on average reduce inputs by at least 67.2% to produce the same amount of output. The number of relatively technical efficient industries remained the same in

2017. Manufacture of malt liquors and malt including nonalcoholic beer, printing of recorded media and manufacture of communication equipment were relatively efficient in the year. About 60% of the sample industries had scored efficiency value less than the average efficiency score of the sample industries, i.e., 0.335. On the other hand, the industries has missed used 66.5% of their scarce resources in 2017, they could have reduced their inputs by 66.5% keeping the current level of output. Surprisingly, manufactures of preparation and spinning of textile fibers continued to be the least inefficient industry with 0.048 score. It reveals the industry poorly allocated and converted its input into output.

Table 2: Technical Efficiency Score of Industries –Constant Return to Scale (CRS)

Decision Making Unit (DMU)	2016	2017	2018	2019	2020	Average
Processing and preserving of fruits and Vegetables	0.397	0.408	0.104	0.075	0.121	0.221
Vegetable and animal oils and fats	0.632	0.502	0.249	0.026	0.071	0.296
Dairy products	0.354	0.277	0.197	0.071	0.073	0.1944
Grain mill products	0.161	0.162	0.378	0.207	0.141	0.2098
Animal feed	0.344	0.696	0.102	0.072	0.068	0.2564
Bakery products	0.157	0.076	0.136	0.204	0.354	0.1854
Manufacture of sugar	0.508	0.53	0.034	0.022	0.034	0.2256
Cocoa, chocolate and sugar confectionery	0.244	0.16	0.095	0.026	0.022	0.1094
Macaroni, noodles, couscous and similar	0.111	0.186	0.262	0.072	0.076	0.1414
Other food products	0.327	0.193	0.173	0.173	0.135	0.2002
Distilled potable alcoholic beverages	0.172	0.184	0.15	0.205	0.191	0.1804
Malt liquors and malt	0.948	1	0.7	0.333	1	0.7962
Soft drinks; production of mineral waters	0.16	0.165	0.218	0.049	0.055	0.1294
Preparation and spinning of textile fibres	0.054	0.048	0.042	0.032	0.059	0.047
Made-up textile articles; except apparel	0.243	0.152	0.226	0.051	0.057	0.1458
Tanning and dressing of leather	0.167	0.675	0.082	0.069	0.154	0.2294
Footwear	0.128	0.13	0.176	0.066	0.068	0.1136
Sawmilling and planing of wood	0.159	0.114	0.081	0.053	0.099	0.1012
Veneer sheets and wood based panels	0.491	0.223	0.22	0.203	0.121	0.2516
Pulp, paper and paperboard	0.386	0.173	0.088	0.101	0.081	0.1658
Other articles of paper and paperboard	0.359	0.497	0.181	0.166	0.165	0.2736
Service activities related to printing	1	0.158	0.049	0.164	0.174	0.309
Printing of recorded media	0.177	1	0.061	0.044	0.049	0.2662
Fertilizers and nitrogen compounds	0.075	0.107	0.087	0.251	0.254	0.1548
Paints, varnishes and similar coatings	0.33	0.349	0.861	0.37	0.697	0.5214

Soap and detergents, cleaning and polishing	0.262	0.159	0.137	0.178	0.134	0.174
Rubber tyres and tubes	0.255	0.695	0.541	0.099	0.184	0.3548
Plastic products	0.267	0.165	0.115	0.064	0.052	0.1326
Glass and glass products	0.224	0.367	0.079	0.084	0.096	0.17
Clay and ceramic building materials	0.094	0.11	0.36	0.069	0.073	0.1412
Cement, lime and plaster	0.24	0.427	0.246	0.128	0.168	0.2418
Articles of concrete, cement and plaster	0.24	0.174	0.087	0.08	0.069	0.13
Cutting, shaping and finishing of stone	0.097	0.13	0.103	0.035	0.034	0.0798
Basic iron and steel	0.324	0.395	0.295	0.097	0.115	0.2452
Structural metal products	0.185	0.157	0.212	0.808	0.727	0.4178
Tanks, reservoirs and containers of metal	1	0.374	0.349	0.261	0.056	0.408
Cutlery, hand tools and general hardware	0.176	0.314	0.058	0.018	0.102	0.1336
Other fabricated metal products	0.32	0.07	1	0.055	0.064	0.3018
Machinery for mining, quarrying	0.293	0.968	1	1	1	0.8522
Other electrical equipment	0.574	0.174	0.137	0.062	0.098	0.209
Communication equipment	0.405	1	0.727	1	1	0.8264
Measuring, testing, navigating and control equipment	0.21	0.355	0.162	0.6	0.26	0.3174
Parts and accessories for motor vehicles	1	0.387	0.257	0.167	0.089	0.38
Furniture	0.17	0.154	0.205	0.134	0.126	0.1578
Mean	0.328	0.335	0.251	0.183	0.199	0.2592

The number of relatively technical efficient industries remained the same in 2017. Manufacture of malt liquors and malt including nonalcoholic beer, printing of recorded media and manufacture of communication equipment were relatively efficient in the year. About 60% of the sample industries had scored efficiency value less than the average efficiency score of the sample industries, i.e., 0.335. On the other hand, the industries has missed used 66.5% of their scarce resources in 2017, they could have reduced their inputs by 66.5% keeping the current level of output. Surprisingly, manufactures of preparation and spinning of textile fibres continued to be the least inefficient industry with 0.048 score. It reveals the industry poorly allocated and converted its input into output. In 2018, only two industries were found efficient (Other fabricated metal products and machinery for mining, quarrying and construction) whereas 42 sample industries are inefficient. As compared to the year 2017, the average efficiency score has declined 8.3% (0.335 in 2017 – 0.251 in 2018), indicating the sector getting worst in resource utilization. Manufacturer of sugar appear to be the least efficient industry in the year and more than half of the sample industries have experienced a decline in efficiency score as compared to the prior year. More importantly, there has been high variation in efficiency score among the industries, which probably caused by

industry size and inherent risk pertaining to each industry. With this regards, previous studies provided several factors for the variation e.g capital expenditure, capital intensity, export performance, etc. (Erena, et al. 2021;).

The number of efficient industries remained constant, two industries in 2019. Namely, Communication equipment and Machinery for mining, quarrying are found to be relatively efficient in using scare resources to produce the optimum level of production. However, the overall score has declined by 6.8% suggesting the sector poorly managed its resources. There has been a bit improve in number of efficient industries and average efficiency sore in 2020. Three industries including Communication equipment, Machinery for mining, quarrying and Malt liquors and malt are relatively efficient in 2020. In overall efficiency score, the sector registered about 25.92% during the observation period. Out of the efficient industries Machinery for mining, quarrying is stayed at the best practice in resource utilization from 2018 to 2020. Nevertheless, preparation and spinning of textile fibres appeared to score in annual average 4.6%, indicating the least inefficient industries during the observation periods. It shows the sector has used excess 74.18% of inputs to produce the current level of output. The sector could have reduced its weighted input usage by 74.18% without reducing the weighted output. Drawing on the results it can be inferred that the manufacturing sector is inefficient in resource usage. This result is also confirmed by Erena et al. (2021) that medium and large manufacturing industries have scored, on average about 37% efficiency value during 2010 to 2017.

BCC Model Results

The BCC model assesses if the efficiency value discovered would be improved by taking increasing, decreasing, or constant returns to scale. When a percentage increase in (all) inputs results in an equal % increase in outputs, or vice versa, this phenomenon is known as constant returns to scale (CRS). On the other hand, proportionate increases in inputs that result in lower or bigger proportionate increases in outputs are known as variable returns to scale (VRS). This BCC model assumption broke down into two parts: a growing return to scale and a diminishing return to scale. An increase in input results in a lesser rise in output when there is a decreasing return to scale. When an increase in inputs results in a greater increase in output, there is an increase in return to scale.

A VRS model assesses the management's effectiveness in using inputs that are free of scale efficiency and permits the best practice level of outputs to inputs to change with industry size.

The CRS technical efficiency of the sample industries is divided into pure technical efficiency and scale efficiency in BCC model. Pure technical efficiency measures the extent to which an industry can decrease its inputs (in fixed proportion) while still remaining within the VRS frontier. Thus technical efficiency measures the industry's overall success at utilizing its inputs. Scale efficiency reflects the extent to which an industry projected to the VRS efficiency frontier can further decrease its inputs (again in fixed proportions) while still remaining within the constant returns to scale frontier. Thus scale efficiency measures the extent to which a firm can reduce inputs by moving to a part of the frontier with more beneficial returns to scale characteristics.

The decomposition is needed to identify the sources of inefficiency by comparing pure technical efficiency and scale efficiency. When pure technical efficiency is higher than that of scale efficiency, the source of inefficiency is due to scale inefficiency (inappropriate selection of scale size). In other words, if there is a difference between the technical efficiency score (CRS technical efficiency and VRS pure technical efficiency), then this demonstrates scale inefficiency. Conversely, if scale efficiency is higher than pure technical efficiency, then the source of inefficiency is due to poor utilization of inputs, i.e., pure technical inefficiency

Table 3 summarizes the results obtained from BCC model variable return to scale (VRS). The results include CRS technical efficiency, VRS technical efficiency and scale efficiency. For simplicity and clarity, I presented a three year (2016, 2017 and 2020) results in table 3 and a two year (2018 and 2019) results are attached in appendix. In 2016, the number of technical efficient industries is three (8), about 6.8 percent of the sample industries when CRS TE is assumed and six (6), about 13.6 percent when VRS TE is assumed. Among the six technically efficient industries, 4 industries are scale efficient suggesting that appropriate selection of inputs and operating on most productive scale size . Whilst two industries are scale inefficient. This reflects that these industries have used inappropriate selection of resource scale size (too large or too small). When looking at the annual average score, scale efficiency value is greater than that of pure technical efficiency score. It indicates that the source of inefficiency is poor management of resources in converting them into output. In addition the value in scale type indicates that 25 industries have experienced a decreasing return to scale i.e., a proportionate increase in inputs

produces a lower proportionate increase in outputs. This implies that the industries have supra-optimal scale size (i.e. operates at the rising portion of long-run average cost curve) and thus, downscaling is needed for achieving efficiency gains. In contrast, three industries experienced an increasing return to scale indicating a proportionate increase in inputs yields a larger proportionate in outputs. These industries would improve their efficiency by expanding the scale of operation. Industries operate at a flatter portion of long-run average cost curve that means constant return to scale. Out of the total sample industries considered in the current study only three industries found technically efficient in CRS model whereas nine industries are efficient under VRS in 2017. The number of efficient industries has significantly improved as compared to the prior observation year. Only three industries are efficient under the two assumptions, CRSTE and VRSTE. The average score of scale efficiency is much higher than pure technical efficiency average score, suggesting the source inefficiency of the sample industries arise due to poor management of resources. Like in the 2016, 25 industries experienced a decreasing return to scale, implying that change in input level produce a smaller proportional of outputs. Whilst 12 industries appeared with an increasing return to scale. Furthermore, about 39 industries had scale inefficiency value that indicates inappropriate choice of scale over the period.

Table 3: Technical Efficiency (TTE), Pure Technical Efficiency (PTE) and Scale Efficiency(SE)

DMU	2016				2017				2020			
	TTE	PTE	SE	Type	TTE	PTE	SE	Type	TTE	PTE	SE	Type
Processing and preserving of fruits and vegetables	0.397	0.398	0.999	irs	0.408	0.411	0.994	irs	0.12	0.185	0.653	drs
Vegetable and animal oils and fats	0.632	0.635	0.995	drs	0.502	0.502	1		0.07	0.108	0.654	drs
Dairy products	0.354	0.354	1		0.277	0.28	0.989	irs	0.07	0.11	0.662	drs
Grain mill products	0.161	0.315	0.513	drs	0.162	0.317	0.512	drs	0.14	1	0.141	drs
Animal feed	0.344	0.526	0.655	drs	0.696	1	0.696	drs	0.07	0.102	0.665	drs
Bakery products	0.157	0.184	0.856	drs	0.076	0.099	0.766	drs	0.35	0.577	0.613	drs
Sugar	0.508	1	0.508	drs	0.53	1	0.53	drs	0.03	0.051	0.659	drs
Cocoa, chocolate and sugar confectionery	0.244	0.244	0.999		0.16	0.16	1		0.02	0.023	0.959	irs
Macaroni, noodles, couscous and similar farinaceous products	0.111	0.19	0.583	drs	0.186	0.186	0.998		0.08	0.101	0.748	drs
Other food products n.e.c	0.327	0.327	1	drs	0.193	0.194	0.996	drs	0.14	0.207	0.65	drs
Distilled potable alcoholic beverages	0.172	0.372	0.462	drs	0.184	0.218	0.842	drs	0.19	0.285	0.671	drs
Malt liquors and malt including non alcoholic beer	0.948	1	0.948	drs	1	1	1		1	1	1	
Soft drinks; production of mineral waters	0.16	0.561	0.285	drs	0.165	0.247	0.667	drs	0.06	0.057	0.972	drs

Preparation and spinning of textile fibres	0.054	0.054	1		0.048	0.05	0.961	drs	0.06	0.084	0.699	drs
Made-up textile articles; except apparel	0.243	0.243	1		0.152	0.153	0.994	drs	0.06	0.082	0.69	drs
Tanning and dressing of leather; dressing and dyeing of fur	0.167	0.167	1		0.675	1	0.675	drs	0.15	0.228	0.673	drs
Footwear	0.128	0.133	0.96	drs	0.13	0.132	0.987	drs	0.07	0.106	0.639	drs
Sawmilling and planing of wood	0.159	0.387	0.412	drs	0.114	0.115	0.991	drs	0.1	0.135	0.734	drs
Veneer sheets and wood based panels	0.491	0.55	0.893	drs	0.223	0.248	0.901	irs	0.12	0.283	0.426	drs
Pulp, paper and paperboard	0.386	0.387	0.999		0.173	0.174	0.996	drs	0.08	0.121	0.674	drs
Other articles of paper and paperboard	0.359	0.359	1		0.497	0.498	0.998	irs	0.17	0.397	0.414	drs
Service activities related to printing	1	1	1		0.158	0.162	0.975	irs	0.17	0.235	0.74	drs
Printing of recorded media	0.177	0.179	0.99	drs	1	1	1		0.05	1	0.049	irs
Fertilizers and nitrogen compounds	0.075	0.182	0.411	irs	0.107	0.213	0.501	irs	0.25	0.329	0.771	drs
Paints, varnishes and similar coatings, printing ink and mastics	0.33	0.33	1		0.349	0.476	0.734	drs	0.7	1	0.697	drs
Soap and detergents	0.262	0.375	0.699		0.159	0.236	0.671	drs	0.13	0.204	0.655	drs
Rubber tyres and tubes	0.255	0.256	0.999		0.695	0.705	0.986	irs	0.18	0.262	0.704	drs
Plastic products	0.267	0.993	0.269	drs	0.165	1	0.165	drs	0.05	0.108	0.483	drs
Glass and glass products	0.224	0.294	0.763	drs	0.367	0.37	0.994	irs	0.1	0.131	0.733	drs
Clay and ceramic building materials e.g non-refractory wall tiles, sanitary fixtures	0.094	0.09	0.999		0.11	0.11	0.997		0.07	0.091	0.799	drs
Cement, lime and plaster	0.24	0.498	0.483	drs	0.427	0.636	0.671	drs	0.17	1	0.168	drs
Articles of concrete, cement and plaster	0.24	0.516	0.464	drs	0.174	0.784	0.221	drs	0.07	0.096	0.723	drs

Cutting, shaping and finishing of stone	0.097	0.137	0.706	drs	0.13	0.132	0.992	drs	0.03	0.05	0.673	drs
Manufacture of basic iron and steel	0.324	1	0.324	drs	0.395	0.863	0.458	drs	0.12	0.165	0.695	drs
Structural metal products	0.185	0.521	0.355	drs	0.157	0.543	0.289	drs	0.73	1	0.722	drs
Tanks, reservoirs and containers of metal of types	1	1	1		0.374	0.376	0.992	drs	0.06	0.094	0.594	irs
Cutlery, hand tools and general hardware	0.176	0.177	0.994	irs	0.314	0.351	0.895	irs	0.1	0.322	0.316	irs
Other fabricated metal products	0.32	0.32	0.999		0.07	0.113	0.616	irs	0.06	0.08	0.794	drs
Machinery for mining, quarrying and construction	0.293	0.411	0.712	drs	0.968	1	0.968	irs	1	1	1	
Other electrical equipment	0.574	0.574	0.999		0.174	0.118	0.925	irs	0.1	0.124	0.79	drs
Communication equipment	0.405	0.041	0.998	drs	1	1	1		1	1	1	
Measuring, testing, navigating and control equipment	0.21	0.393	0.534	drs	0.355	0.517	0.687	drs	0.26	0.348	0.748	drs
Parts and accessories for motor vehicles	1	1	1		0.387	0.415	0.933	drs	0.09	0.199	0.447	irs
Furniture	0.17	0.175	0.971	drs	0.154	1	0.154	drs	0.13	0.197	0.641	drs
Mean	0.328	0.437	0.789		0.335	0.459	0.802		0.2	0.324	0.658	

Where: TTE total technical efficiency score under CRS; PTE pure technical efficient and free from scale efficiency; SE – scale efficiency and type - scale type

When looking at the last year, 2020, in average, total technical efficiency score has significantly declined by 13.5% from 2018 to 2020. Since the year 2020 was the year of Corona virus outbreak which caused a large volume of devastation in all aspects of an economy. Thus, lower score observed here was partly due to the pandemic. As can be seen in table 3, pure technical efficiency is lower than that of scale value. It implies that the source of inefficiency score continued to be because of poor usage of input resources. Most of sample industries experienced a decreasing return to scale in 2020. During the three years, in overall results, Malt liquors and malt including non-alcoholic beer appeared to be the most efficient industry followed by Communication equipment industry. In gist, the sector is characterized by poor resources management and usage in converting those inputs into outputs. It can be concluded that the sector should critically look into its scarce resources utilization in order to attain the maximum benefit from the utilization of resources.

MALMQUIST INDEX SUMMARY OF FIRM RESULTS

The Malmquist index evaluates the productivity changes over time. In the non-parametric framework, it is measured as the product of catch-up (recovery) and frontier-shift (innovation) terms, both coming from the DEA technologies. The catch-up term relates to the degree that a DMU attains for improving its efficiency, while the frontier-shift term reflects the change in the efficient frontiers surrounding the DMU between the two time periods (Cooper, et al, 2004).

The investigation of productivity growth is achieved by applying a non-parametric method developed by Fare et al. (1989) which computes total factor productivity (TFP) growth using a Malmquist index of productivity change. The Malmquist index can be decomposed to capture the two components, technological change and technical efficiency change. Technical efficiency can be further decomposed into a pure technical efficiency and a scale efficiency change components. The change in technical efficiency is described as the efficiency in reaching to the production limit and technological change described as the curve shift in productivity limit.

If the value of Malmquist index or any of its components is less than 1, that denotes regress or deterioration in performance, whereas values greater than one denote improvements in the relevant

performance (Fare *et al.*, 1994). To compute the Malmquist index a panel dataset of 15 major groups of industries are used. The dataset ranges from 2007 to 2020.

Table 4 summarizes the Malmquist index mean summary of the major industrial groups. With regards to technical change FABRICATED METAL PRODUCTS found with insignificant technical progress, 0.04% TOBACCO PRODUCTS remained constant during the observation periods. The rest 13 industries experienced technical deterioration. Among the industries with regress score, OTHER NON-METALLIC MINERAL PRODUCTS has the highest technical regress, 15.9%. Moreover, the sector registered a technical regress over the study time period. It implies that the industries had not made improvement in utilization of the scare resources in producing outputs. When looking at the average score of change in technology, the sector showed about 10.8% progress during the study period. All individual industries also appeared to have technological improvement. About 86.6% (13 industries) of industries had a productivity growth and two industries registered productivity deterioration. Among the industries with progress, CHEMICALS AND CHEMICAL PRODUCTS had the largest score, 16% where as BASIC IRON AND STEEL showed the smallest progress 1.5%. The value on total productivity index, 1.054 indicates that productivity growth by 5.4% from 2007 to 2020. The change in highly contributed by technological progress. These results are in line with the work of Sturm and Kumar & Gulati (2018) which states that the main source of efficiency improvement was technological change rather than technical efficiency change.

Table 4 Average TFP and its components' change of Major Industries from 2007 to 2020

DMU	TECH	TECHCH	PECH	SECH	TPCH
FOOD PRODUCTS AND BEVERAGES	0.934	1.105	1	0.934	1.032
TOBACCO PRODUCTS	1	1.069	1	1	1.069
TEXTILES	0.95	1.175	0.982	0.967	1.116

WEARING APPAREL, EXCEPT FUR APPAREL	0.971	1.076	0.961	1.011	1.045
FOOTWEAR, LUGGAGE AND HANDBAGS	0.948	1.142	0.959	0.988	1.083
WOOD AND OF PRODUCTS OF WOOD AND CORK	0.94	1.084	0.909	0.995	1.03
PAPER, PAPER PRODUCTS AND PRINTING	0.945	1.089	0.971	0.973	1.03
CHEMICALS AND CHEMICAL PRODUCTS.....	0.995	1.166	1.012	0.983	1.16
RUBBER AND PLASTIC PROCDUCTS.....	0.94	1.05	1.003	0.937	0.987
OTHER NON-METALLIC MINERAL PRODUCTS ...	0.841	1.163	0.934	0.9	0.979
BASIC IRON AND STEEL	0.955	1.063	0.95	1.006	1.015
FABRICATED METAL PRODUCTS	1.004	1.177	1.004	1	1.182
MACHINERY AND EQUIPMENT N.E.C.	0.978	1.052	1	0.978	1.029
MOTOR VEHICLES,TRAILERS & SEMI-TRAILERS	0.997	1.091	1.018	0.979	1.088
FURNITURE; MANUFACTURING N.E.C	0.959	1.133	0.957	1.003	1.087
Mean	0.954	1.108	0.977	0.977	1.057

Source: Own computation from panel data by using DEAP version 2.1

- Notes: - TECH – technical efficiency change
- TECHCH – technological change
- PECH – pure technical efficiency change
- SECH– scale efficiency change
- TPCH – total factor productivity change

Table 5 describes the Malmquist index annual means and its components of the 15 major industries group under investigation for the study period (2007 -2020). During the period, technical efficiency change decreased on average by 4.6 percent. In contrast, technology change increased by 10.8 percent. Since technical efficiency change is decomposed into pure technical and scale efficiency change, total percent of deterioration in technical efficiency is the result of both pure technical efficiency and scale efficiency regress.

Table 5: MALMQUIST INDEX SUMMARY OF ANNUAL MEANS

Year	TECH	TECHCH	PECH	SECH	TPCH
2007	0.621	1.400	0.766	0.811	0.870
2008	0.891	1.256	0.971	0.918	1.119

2009	0.667	1.342	0.826	0.808	0.895
2010	1.147	0.866	1.101	1.042	0.994
2011	1.325	1.15	1.077	1.231	1.524
2012	1.172	1.38	1.464	0.801	1.618
2013	0.621	1.4	0.766	0.811	0.87
2014	1.004	0.976	0.889	1.13	0.98
2015	1.1106	0.786	1.02	1.085	0.869
2016	0.76	1.944	1.216	0.625	1.477
2017	0.328	3.738	0.7	0.468	1.225
2018	0.91	1.019	1.044	0.871	0.927
2019	2.86	0.194	0.74	3.864	0.556
2020	1.143	1.063	1.161	0.984	1.215
Mean	0.954	1.108	0.977	0.977	1.057

Specifically, the highest productivity growth has been registered, 61.8% and followed by 52.4% in 2011. Conversely, a larger deterioration in productivity is observed in 2019 that is one year lagging to pandemic outbreak. However, following 2012, there has been significant decline in productivity for three consecutive years (2013-2015). Again the sector experienced a progress for two years 2016 and 2017 and got deterioration in 2018 and 2019. One can easily understand from the trend that the productivity growth is not stable in the long time and stayed in similar region (progress or regress region) for a short period of time. One important result here is that the sector had showed a positive growth, 21.5% during the COVID outbreak, 2020. My result is consistent with prior studies in Ethiopia (e.g, Erena et al., 2021; Hailu & Tanaka, 2015; Abegaz,2013) that large and medium manufacturing industries showed progress in total productivity.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1. CONCLUSION

Today is the era of dynamic and competitive world. Measurement is the way of managing these dynamic and competitive situations. Such conditions necessitate the detail understanding of technical efficiency of manufacturing sector which entertain moderate competition when compared to other sectors working in our country Ethiopia. Therefore, the aim of this paper is to investigate the relative technical efficiency of large and medium manufacturing industries operating in Ethiopia using Data Envelopment Analysis (DEA). For measuring relative technical efficiency both under Constant Return to Scale (CRS) and Variable Return to Scale (VRS) Models 44 sub industries were purposely selected from 79 sub industries with dataset ranging 2016 to 2020. To compute factory productivity growth index, the available 15 major industries groups were used with dataset ranging from 2007 to 2020. Two input variables and two output variables were employed for the analysis. The input variables are Total Fixed Assets and total number of employees, whereas the output variables are Value Added at current national price and Operating Surplus. Dataset was obtained from Ethiopian Statistical Service.

Based on the CCR model, it is found that the average technical efficiency of sample industries between 2016 and 2020 ranges from the least 0.047 to the highest 0.8522 with the overall mean of the five year equal to 0.2592. When BCC model is assumed, however, it is found that the average pure technical efficiency ranges between 0.324 % and 0.459 %. This indicates that the manufacturing sector is on average relatively technically inefficient.

In addition, decomposing technical efficiency into pure technical efficiency and scale efficiency provides an insight about the source of inefficiency. Based on the analysis made using BCC model, I found an average pure technical efficiency score is less than that of scale efficiency from this I can conclude that the major source of inefficiency of the sample industries is pure inefficiency. On the other hand, these industries are relatively inefficient in allocation of resources in to input and output mix than scale of operation.

Moreover, the study also finds that more than half of the sample industries experienced a decreasing return to scale in all efficiency scores (TTE, PTE & SE). This indicates that almost all inefficient industries operate at a declining portion of long-run average cost curve (i.e. they have

sub-optimal scale size). So, these industries should expand their business by deploying more resources.

In the Malmquist productivity index, the total factor productivity change shows on average 5.7 progresses which show growth over the observation periods. Decomposing the measures of MPI into technical efficiency change and technological change provides the insight reasons of total factor productivity change. The result shows that the average annual technical efficiency of the sector is 0.954 indicating deterioration in technical efficiency. In addition, by decomposing technical efficiency change further into pure technical efficiency change and scale efficiency change, the results show that the average pure technical efficiency change is 0.977 and scale efficiency change has same score 0.977. This indicates that the reason for technical efficiency regress is due to both pure technical efficiency or management inefficiency and scale of operation. This result confirms the prior studies by Kumar & Gulati (2018) which states that the main source of efficiency improvement was technological change rather than technical efficiency changes.

5.2. RECOMMENDATIONS

Drawing on the findings the study forwarded the following recommendations for the sector.

As indicated in the analysis the manufacturing industries are on average technically inefficient during the study period (2016-2020). The reason of inefficiency score was on average due to pure inefficiency. Thus, the study recommends that the sector should take care about input usage in converting them into output. Majority of the sample inefficient industries experienced a decreasing return to scale. So, the study recommends that the managers of these industries should enhance their performance by deploying more resources to improve efficiency level.

The study also recommends that in order to pursue additional regulatory and advisory practices, the relevant government unit should consider the possible improvements needed for each input and output variable. This pertains to the government's role in creating policy and providing advice.

Finally, the patterns of technical efficiency change over the last 14 years (from 2007 to 2020) indicate a decline trend, which can be attributed to both scale inefficiency and management efficiency (PTE) regression in resource allocation to input-output mix. In the age of limited

resources and intense competition, having high-quality management is essential to winning business and offering products at the lowest possible cost. According to the study, industries should try to minimise management inefficiencies and scale inefficiencies. This can be achieved by assigning competitively talented human resources, training the current managers, etc. This means that industries need to set up extension programmes meant to accelerate the adoption of new technology, as well as education and training programmes in order to enhance management skills.

❖ **Policy and Practical Implications:**

- Improving the manufacturing sector's efficiency has important implications for policymakers, government officials, and industry managers.
- Efficient utilization of resources can optimize productivity and contribute more significantly to the economy.

The study's findings could provide valuable insights for further research projects, particularly for masters and PhD students interested in this field.

The manufacturing sector in Ethiopia demonstrated significant inefficiency in resource usage.

- Consistent inefficiency in certain sub-industries points to a need for better resource management and optimization practices.
- The sector could benefit from adopting best practices from relatively efficient industries to improve overall performance.
- Technological upgrades and better input management strategies could help improve efficiency scores and productivity growth across the sector.
- By addressing these inefficiencies, the Ethiopian manufacturing sector can enhance its productivity and competitiveness in the global market.

References

Abegaz, M. T. (2013). *Total factor productivity and technical efficiency in the Ethiopian manufacturing sector* (No. 010).

Addis Ababa Chamber of Commerce and Sectoral Association (AACCSA) October 2015 Analysis, (*London: Kluwer Academic Publishers*).

Banker, R.D., Charnes, A., and Cooper, W.W.(1984). Some models for estimating technical and scale inefficiencies in DEA. *Management Science*, Vol.30, No.9, 1078-1092.

Befekadu, D. and Berhanu, N. 2002. Annual Report on the Ethiopian Economy, the Ethiopian Economic Association, Vol. I.

Bhat, R., Bhushan, B. and Reuben, E. (2001). An empirical analysis of district hospitals and grant-in-aid hospitals in Gujarat state of India, Indian Institute of Management.

Bhatia, D.P., (1990), Misleading growth rates in the manufacturing sector of India, *International journal of strategic organization and Behavior science*, volume2, number 1

Bowlin, William F., Charnes, A., and Cooper, W. W. (2002). Efficiency and effectiveness in DEA: An illustrative application to base maintenance activities in the U.S. air force. *Working Papers in cost benefit analysis*, Mellon University

Charnes, A., Cooper, W.W., and Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of operations research* Vol.2, No.6, 429-444.

Coelli, T. (1996). A guide to DEAP Version 2.1, A Data Envelopment Analysis (Computer) Program”, *CEPA Working Paper 96/08, University of New England, Australia*

Coelli, T., P. Rao and G.E Battese (2002). An Introduction to Efficiency and Productivity

Colwell, R. J. and Davis, E. P. (1992). Output and Productivity in Banking, *the Scandinavia journal of economics*.

Creswell, W(2009). Advanced mixed. *Handbook of mixed methods in social & behavioral research*, 209.

Creswell, W(2009). Advanced mixed. *Handbook of mixed methods in social & behavioral research*, 209.

CSA (2018). Report on large and medium scale manufacturing and electricity industries survey. The FDRE Statistical Bulletin.

CSA (Central Statistical Authority) 2001. Report on Large and Medium Scale Manufacturing and Electricity Industries Survey. Statistical Bulletin 248. Addis Ababa, Ethiopia.

- CSA report (2022). Large and Medium Scale Manufacturing and Electricity Industries Survey Data, CSA, Addis Ababa
- Diao, X., Ellis, M., McMillan, M. S., & Rodrik, D. (2021). *Africa's manufacturing puzzle: Evidence from Tanzanian and Ethiopian firms* (No. w28344). National Bureau of Economic Research.
- Drake, L. (2001). Efficiency and Productivity change in UK banking. *Applied Financial Economics* 11, pp 557-571
- Erena, O. T., Kalko, M. M., & Debele, S. A. (2021). Technical efficiency, technological progress and productivity growth of large and medium manufacturing industries in Ethiopia: A data envelopment analysis. *Cogent Economics & Finance*, 9(1), 1997160.
- Erena, O. T., Kalko, M. M., & Debele, S. A. (2021). Technical efficiency, technological progress and productivity growth of large and medium manufacturing industries in Ethiopia: A data envelopment analysis. *Cogent Economics & Finance*, 9(1), 1997160.
- Gupta, K.O., Doshit, Y. & Chinubhai,A. (2008). Dynamics of Productive Efficiency of Indian Banks: *International Journal of Operations Research*, 5 (2), 78- 90.
- Hailu, K. B., & Tanaka, M. (2015). A “true” random effects stochastic frontier analysis for technical efficiency and heterogeneity: Evidence from manufacturing firms in Ethiopia. *Economic Modelling*, 50, 179-192.
- Hill, H., & Kalirajan, K. P. (1993). Small enterprise and firm-level technical efficiency in the Indonesian garment industry. *Applied Economics*, 25(9), 1137-1144.
- Hill, H., & Kalirajan, K. P. (1993). Small enterprise and firm-level technical efficiency in the Indonesian garment industry. *Applied Economics*, 25(9), 1137-1144.
- Indirs J.and Rahmah I. (2006) “Technical efficiency, technological change and total factor productivity growth in Malaysian manufacturing sector” Online at <http://mpra.ub.uni-muenchen.de/1956/> MPRA Paper No. 1956, posted 28. February 2007
- Kumar, S. and Gulati, R., (2018). An Examination of Technical, Pure Technical, and Scale Efficiencies in Indian Public Sector Banks using Data Envelopment Analysis, *Eurasian Journal of Business and Economics*, 1 (2), 33-69.

Kumar, S. and Gulati, R., (2018). An Examination of Technical, Pure Technical, and Scale Efficiencies in Indian Public Sector Banks using Data Envelopment Analysis, *Eurasian Journal of Business and Economics*, 1 (2), 33-69.

OECD. (2001). Measuring Productivity: Measurement of Aggregate and Industry Level Productivity Growth. OECD manual. Organisation for Economic Co-operation and Development: Paris

OECD. (2001). Measuring Productivity: Measurement of Aggregate and Industry Level Productivity Growth. OECD manual. Organisation for Economic Co-operation and Development: Paris

Oqubay, A. (2019). The structure and performance of the Ethiopian manufacturing sector. Pickett, J. 1991. Economic Development in Ethiopia: Agriculture the Market and the State, OECD Development Center Studies, Paris

Rama M. R and Simon Z. T (2015) 'Performance measurement of manufacturing industries in Ethiopia: An analytical study' Journal of Poverty, Investment and Development ISSN 2422-846X An International Peer-reviewed Journal Vol.7, 2015

Schreyer, P., & Pilat, D. (2002). Measuring productivity. OECD Economic studies, 2001(2), 127-170.

Schreyer, P., & Pilat, D. (2002). Measuring productivity. OECD Economic studies, 2001(2), 127-170.

Shiferaw, A., & Söderbom, M. (2018). The Ethiopian manufacturing sector: Productivity, export orientation, and competitiveness.

Syverson, C. (2011). What Determines Productivity? Journal of Economic Literature, 9(2), 326–365.

Syverson, C. (2011). What Determines Productivity? Journal of Economic Literature, 9(2), 326–365.

Tekleselassie, T. G., Berhe, K., Getahun, T. D., Abebe, G., & Ageba, G. (2018). Productivity Determinants in the Manufacturing Sector in Ethiopia: Evidence from the Textile and Garment Industries. *Ethiopian Development Research Institute (EDRI)*.

Tekleselassie, T. G., Berhe, K., Getahun, T. D., Abebe, G., & Ageba, G. (2018). Productivity Determinants in the Manufacturing Sector in Ethiopia: Evidence from the Textile and Garment Industries. *Ethiopian Development Research Institute (EDRI)*.

United Nation SDG Report (2021) <https://unstats.un.org/sdgs/report/2021/goal>

09/#:~:text=The%20share%20of%20manufacturing%20value,cent%20to%2016.0%20per%20nt.

University, Dissertation Abstracts International 42(8), 3731A, University Micro@lms No.

Appendices

EFFICIENCY SUMMARY -2018

firm crste vrste scale

1	0.104	0.246	0.424	drs
2	0.249	0.317	0.788	drs
3	0.197	0.222	0.888	drs
4	0.378	1.000	0.378	drs
5	0.102	0.116	0.883	drs
6	0.136	0.161	0.847	drs
7	0.034	0.039	0.865	drs
8	0.095	0.095	0.999	-
9	0.262	0.275	0.952	drs
10	0.173	0.187	0.923	drs
11	0.150	0.151	0.996	irs
12	0.700	1.000	0.700	drs
13	0.218	0.796	0.274	drs
14	0.042	0.045	0.918	drs
15	0.226	0.352	0.642	drs
16	0.082	0.117	0.698	drs
17	0.176	0.388	0.453	drs
18	0.081	0.124	0.649	drs
19	0.220	0.260	0.844	drs
20	0.088	0.089	0.995	-
21	0.181	0.200	0.906	drs
22	0.049	0.050	0.982	drs

23 0.061 1.000 0.061 irs
 24 0.087 0.218 0.400 irs
 25 0.861 1.000 0.861 drs
 26 0.137 0.158 0.868 drs
 27 0.541 0.587 0.922 drs
 28 0.115 0.362 0.318 drs
 29 0.079 0.081 0.980 irs
 30 0.360 0.423 0.850 drs
 31 0.246 0.375 0.655 drs
 32 0.087 0.126 0.690 drs
 33 0.103 0.244 0.424 drs
 34 0.295 0.935 0.316 drs
 35 0.212 0.626 0.339 drs
 36 0.349 0.471 0.741 irs
 37 0.058 0.132 0.443 irs
 38 1.000 1.000 1.000 -
 39 1.000 1.000 1.000 -
 40 0.137 0.147 0.932 irs
 41 0.727 0.786 0.925 drs
 42 0.162 0.165 0.979 drs
 43 0.257 1.000 0.257 irs
 44 0.205 0.670 0.306 drs

mean 0.251 0.403 0.711

Note: crste = technical efficiency from CRS DEA
 vrste = technical efficiency from VRS DEA
 scale = scale efficiency = crste/vrste

EFFICIENCY SUMMARY - 2019

firm crste vrste scale

1 0.075 0.121 0.620 drs
 2 0.026 0.041 0.637 drs
 3 0.071 0.111 0.637 drs
 4 0.207 1.000 0.207 drs
 5 0.072 0.122 0.585 drs
 6 0.204 0.303 0.673 drs
 7 0.022 0.047 0.472 drs
 8 0.026 0.026 0.984 -
 9 0.072 0.103 0.697 drs
 10 0.173 0.433 0.400 drs

11 0.205 0.341 0.602 drs
 12 0.333 0.855 0.390 drs
 13 0.049 0.103 0.474 drs
 14 0.032 0.045 0.697 drs
 15 0.051 0.078 0.653 drs
 16 0.069 0.095 0.731 drs
 17 0.066 0.146 0.455 drs
 18 0.053 0.082 0.646 drs
 19 0.203 0.445 0.457 drs
 20 0.101 0.159 0.639 drs
 21 0.166 0.370 0.447 drs
 22 0.164 0.237 0.693 drs
 23 0.044 1.000 0.044 irs
 24 0.251 0.356 0.705 drs
 25 0.370 0.538 0.688 drs
 26 0.178 0.389 0.457 drs
 27 0.099 0.155 0.641 drs
 28 0.064 0.122 0.521 drs
 29 0.084 0.137 0.613 drs
 30 0.069 0.111 0.619 drs
 31 0.128 0.366 0.350 drs
 32 0.080 0.156 0.511 drs
 33 0.035 0.048 0.724 drs
 34 0.097 0.258 0.376 drs
 35 0.808 1.000 0.808 drs
 36 0.261 0.265 0.985 irs
 37 0.018 0.278 0.064 irs
 38 0.055 0.077 0.717 drs
 39 1.000 1.000 1.000 -
 40 0.062 0.070 0.892 drs
 41 1.000 1.000 1.000 -
 42 0.600 1.000 0.600 drs
 43 0.167 0.270 0.619 irs
 44 0.134 0.193 0.695 drs

mean 0.183 0.319 0.601

Note: crste = technical efficiency from CRS DEA

vrste = technical efficiency from VRS DEA

scale = scale efficiency = crste/vrste

MALMQUIST INDEX SUMMARY OF ANNUAL MEANS

year effch techch pech sech tfpch

2 0.891 1.256 0.971 0.918 1.119
 3 0.667 1.342 0.826 0.808 0.895
 4 1.147 0.866 1.101 1.042 0.994
 5 1.325 1.150 1.077 1.231 1.524
 6 1.172 1.380 1.464 0.801 1.618
 7 0.621 1.400 0.766 0.811 0.870
 8 1.004 0.976 0.889 1.130 0.980
 9 1.106 0.786 1.020 1.085 0.869
 10 0.760 1.944 1.216 0.625 1.477
 11 0.328 3.738 0.700 0.468 1.225
 12 0.910 1.019 1.044 0.871 0.927
 13 2.860 0.194 0.740 3.864 0.556
 14 1.143 1.063 1.161 0.984 1.215

mean 0.954 1.108 0.977 0.977 1.057

MALMQUIST INDEX SUMMARY OF FIRM MEANS

firm effch techch pech sech tfpch

1 0.934 1.105 1.000 0.934 1.032
 2 1.000 1.069 1.000 1.000 1.069
 3 0.950 1.175 0.982 0.967 1.116
 4 0.971 1.076 0.961 1.011 1.045
 5 0.948 1.142 0.959 0.988 1.083
 6 0.904 1.084 0.909 0.995 0.980
 7 0.945 1.089 0.971 0.973 1.030
 8 0.995 1.166 1.012 0.983 1.160
 9 0.940 1.050 1.003 0.937 0.987
 10 0.841 1.163 0.934 0.900 0.979
 11 0.955 1.063 0.950 1.006 1.015
 12 1.004 1.177 1.004 1.000 1.182
 13 0.978 1.052 1.000 0.978 1.029
 14 0.997 1.091 1.018 0.979 1.088
 15 0.959 1.133 0.957 1.003 1.087

mean 0.954 1.108 0.977 0.977 1.057

[Note that all Malmquist index averages are geometric means]

Raw data of 15 Major industries

Year	Value Added	Operating Surplus	Fixed Assets	Number of employees
2007	2792055	1358671	2518523	35686

2007	283167	114449	157695	799
2007	331423	73740	603359	21702
2007	97940	2035	293871	7604
2007	257955	79857	599020	8351
2007	41799	15412	14399	2010
2007	369239	175889	281951	8161
2007	365611	151321	433029	7030
2007	354673	161332	548301	7619
2007	1397838	977895	1006041	11137
2007	325723	110525	317100	1923
2007	355495	224279	252256	3517
2007	3970	1622	4552	171
2007	347419	150782	297111	3131
2007	131382	60013	137697	5713
2008	3876935	1692433	3651207	41265
2008	344048	153672	143866	1254
2008	185022	2198	298343	10610
2008	114544	1033	313884	7613
2008	366216	170879	607603	8586
2008	54133	16327	10908	3166
2008	470942	183265	329712	8917
2008	530710	249228	464372	7762
2008	445516	183210	690351	8727
2008	1707345	1146982	1117180	16853
2008	280055	118084	120502	1328
2008	442180	165702	376844	5180
2008	6688	3057	7374	185
2008	168299	103320	123780	1725
2008	162072	68650	216933	7134
2009	4718007	2150387	3861358	44957
2009	472882	355082	155358	1122
2009	521126	218298	686673	16466
2009	75649	34400	557813	7793
2009	314469	125797	631285	8750
2009	43172	12344	174836	2111
2009	591877	299899	323925	8822
2009	912626	577575	573153	8031
2009	701171	334304	842125	11958
2009	1696174	1029018	1635445	19790
2009	417784	202376	254682	1710

2009	554351	269163	366104	5884
2009	9379	4343	8718	170
2009	155004	80088	116736	1684
2009	251198	109000	256231	7945
2010	6854566	3105815	4647296	60110
2010	367544	36704	140796	986
2010	907567	498416	1762262	21382
2010	230285	53869	541478	9342
2010	404512	145522	833376	10707
2010	33076	-28966	375396	3261
2010	755666	394032	779239	9998
2010	1295464	739013	808262	11185
2010	1217011	649906	1127737	13859
2010	2703684	1934407	2332869	19482
2010	413524	108504	571386	4016
2010	1180118	617233	1145771	9977
2010	84167	42383	106300	859
2010	344562	231470	115075	1671
2010	543586	363633	237046	8251
2011	12288032	6845097	4518756	67072
2011	346641	201002	77199	1342
2011	388953	29368	611916	13431
2011	245322	157361	160982	5802
2011	1377223	944334	1079836	14019
2011	164747	67137	376666	3988
2011	1013965	562650	880074	10076
2011	1765557	1114791	1004814	9744
2011	1103742	582436	902460	10984
2011	2764125	1809337	2435144	17230
2011	845823	416003	776145	4927
2011	-569976	1169129	920221	6040
2011	93731	53490	84780	648
2011	254192	101321	121593	1623
2011	359924	213556	286607	6471
2012	10228742	2007254	7208293	54492
2012	346641	201002	66491	1342
2012	321370	2419145	3479168	2245
2012	498903	888013	577765	11669
2012	1368459	1212934	1468650	15126
2012	36008	1063278	270059	4055

2012	892356	431063	962083	9013
2012	2139058	1179776	1229859	11028
2012	1618937	775840	1323118	12745
2012	5204890	3290841	9167848	24278
2012	843824	417881	759292	3350
2012	2114781	1088365	2081338	8421
2012	3647	2063	25769	48
2012	536553	421528	156369	1584
2012	907282	482803	431731	8342
2013	13937926	6316385	11299142	52441
2013	568921	332583	150704	431
2013	1136216	2318668	4572122	34483
2013	60853	142141	344994	8016
2013	2678713	751517	1764952	18311
2013	147949	1051581	371407	5577
2013	1242433	536702	2735992	9720
2013	3795950	2340446	1932638	14244
2013	2269637	1194913	1544370	63527
2013	5499074	3745768	9633962	37172
2013	1027868	482592	678138	3754
2013	2973272	1454276	3413321	13396
2013	69010	35601	55563	379
2013	1843333	1165824	683821	5168
2013	825816	346605	796181	10235
2014	18460726	9608787	13519249	55970
2014	568921	332583	150704	431
2014	817565	617913	6095992	56386
2014	620408	412475	304673	6746
2014	2920207	1892204	1706020	18690
2014	69997	28598	210221	3189
2014	1680265	790877	1346212	13245
2014	3976093	2430349	2012404	14920
2014	3517326	2037959	2176038	17868
2014	7593082	5245665	8260209	28609
2014	1393182	578911	1020372	3487
2014	3253317	1581854	2118634	61550
2014	316466	181782	438333	1967
2014	1176128	223665	356283	4500
2014	1131656	417419	600749	8797
2015	25837566	16796490	21487719	63790

2015	907068	571803	307197	2246
2015	1651010	154261	4874833	30540
2015	330322	121439	269502	6106
2015	2044120	1161164	1697014	17122
2015	240092	97759	269689	3642
2015	1777945	908146	1310659	9536
2015	3295819	1267386	2256771	14201
2015	1884381	230991	2631298	19662
2015	7323881	4334067	18739474	28198
2015	3137260	559674	2686889	8130
2015	3589034	2539555	3395760	9290
2015	248130	120249	444130	1821
2015	4143871	3065415	1530150	4581
2015	1642929	45224	1587464	12227
2016	29207979	15813327	34184937	59152
2016	1805598	1094132	351381	564
2016	1647140	545720	3347729	27699
2016	1880038	1512137	528842	13029
2016	1301826	553667	1337714	15055
2016	389401	274314	137230	21159
2016	3193462	2262952	1344280	9468
2016	4028016	2327238	2379874	14031
2016	4877302	1852304	3476442	21355
2016	9201795	5631292	15321845	36421
2016	3752556	2582636	2633176	5451
2016	3879646	2397643	4274367	10770
2016	1598258	1229243	3109117	2832
2016	2047501	999259	1355149	6719
2016	1639555	646522	1331643	14894
2017	29285275	20168598	35257226	61760
2017	1827733	1798176	21543	549
2017	2027950	1219675	2623416	35590
2017	7891430	6964773	965032	15419
2017	3182328	2627708	1230474	13958
2017	300067	185965	289753	2504
2017	6437856	5147825	9972986	9788
2017	3881975	2644953	3076837	17110
2017	5858426	4021293	4042922	42900
2017	14716364	9860767	22170955	35407
2017	4299569	2812215	3977363	6371

2017	2999745	1845461	2410480	12500
2017	505198	378418	52526499	2490
2017	2703920	1680361	1973915	6847
2017	7279178	6390705	4999207	29865
2018	43336392	25216097	51844639	83540
2018	1827733	1798176		549
2018	3226677	1798176	6095260	31870
2018	770611	32924	718922	14633
2018	599155	1695845	1797403	20068
2018	329205	173007	271021	2491
2018	5678070	4375525	3480839	14707
2018	7051337	5300323	4611309	16675
2018	5842278	3415568	4937650	45387
2018	14966073	9994166	34530267	45387
2018	6347234	5024542	3840168	6991
2018	8718303	6862709	5474114	15996
2018	794619	642141	482461	3096
2018	403727	11978	277095	2218
2018	6370495	5432050	5187405	13125
2019	27101735	16955617	37206750	87899
2019	1138384	1012946	310715	1076
2019	330247	1012946	5458505	29017
2019	587413	-46944	1946018	35649
2019	239150	986396	3455784	9918
2019	1063864	665452	6194290	7589
2019	4395080	1555013	3791636	29287
2019	5253980	3109516	4071705	15054
2019	5406250	3322687	7937650	77602
2019	8707200	4176814	40840033	77602
2019	3217106	1344705	8730175	8863
2019	7468823	6481955	2144161	7813
2019	103776	55881	100392	602
2019	674185	615046	587008	901
2019	2132591	1634947	1964819	8147
2020	30195856	19400162	52541679	90703
2020	1138384	1012946	310715	1076
2020	2774611	1012946	5486561	28475
2020	813254	151434	1917057	35972
2020	445366	1217554	3424724	10504
2020	1145225	633962	1165145	7708

2020	4755449	2019146	3778714	28872
2020	5586943	3430968	3790095	11040
2020	4738623	2511405	7868124	78524
2020	10320496	5518164	40890883	78524
2020	3491397	1449542	7656013	8950
2020	7738165	6705985	2297065	6223
2020	108470	60208	91315	607
2020	650809	607554	730025	897
2020	2054263	1543976	1967838	8448

List of the Major Groups of Industries

1	MANUFACTURE OF FOOD PRODUCTS AND BEVERAGES.....
2	MANUFACTURE OF TOBACCO PRODUCTS
3	MANUFACTURE OF TEXTILES
4	MANUFACTURE OF WEARING APPAREL, EXCEPT FUR APPAREL....
5	TANNING AND DRESSING OF LEATHER; MANUFACTURE OF FOOTWEAR, LUGGAGE AND HANDBAGS ..
6	MANUFACTURE OF WOOD AND OF PRODUCTS OF WOOD AND CORK, EXCEPT FURNITURE
7	MANUFACTURE OF PAPER, PAPER PRODUCTS AND PRINTING
8	MANUFACTURE OF CHEMICALS AND CHEMICAL PRODUCTS.....
9	MANUFACTURE OF RUBBER AND PLASTIC PROCDUCTS.....
10	MANUFACTURE OF OTHER NON-METALLIC MINERAL PRODUCTS ...
11	MANUFACTURE OF BASIC IRON AND STEEL.....
12	MANUFACTURE OF FABRICATED METAL PRODUCTS EXCEP MACHINERY AND EQUIPMENT
13	MANUFACTURE OF MACHINERY AND EQUIPMENT N.E.C.
14	MANUFACTURE OF MOTOR VEHICLES,TRAILERS & SEMI-TRAILERS
15	MANUFACTURE OF FURNITURE; MANUFACTURING N.E.C.