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Examining Technical Efficiency of Wood-Based Industries in Ethiopia

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Abstract

Technical efficiency is crucial for the advancement and growth of contemporary enterprises and is a major area of policy concern in many countries. Numerous pieces of evidence suggest that Ethiopia's industries, particularly those depend on wood were not operating as efficient as they should be. As a result, the country is not benefiting as much from the sector as it ought to, and it is now compelled to import wooden products at a higher cost in foreign exchange. Therefore, to examine the technical efficiency of the industries; four purposively selected main cities such as Addis Ababa, Hawassa, Jima and Bahir Dar were selected. From these cities, information was collected, analyzed, and the results were obtained. The result shows that the technical efficiency of Ethiopia's wood industries is lower than expected. Out of a total of 170, about 149 (87.6 %) of the furniture workshops are technically inefficient. This is because workers working in the wood industries are less educated. In addition to this lack of on-the-job training, lack of modern machineries and insufficient skills to use them properly, inconvenient production and sales area, shortage and quality of raw materials, insufficient capital, lack of market connection, have been shown to be the reasons. Therefore, to improve the technical efficiency of the industries, it is better to have continuous vocational training, loan support so that they can get and use better machines, as well as convenient manufacturing, product display and sales, improving and facilitating market linkages.

Keywords: Technical efficiency, Wood industry, Furniture, Ethiopia, Machinery

1. Introduction

Wood-based industries play a pivotal role in the socio-economic development of many countries, including Ethiopia. The utilization of wood resources not only contributes significantly to the country's GDP but also provides employment opportunities, where alternative sources of income are limited (Banaś, J. et al., 2021). However, the efficiency of these industries in utilizing available resources remains a critical concern for policymakers and stakeholders alike.

Technical efficiency is important for the improvement and development of modern industries and contributing to the country's economy and are the focus of policy issues in many countries (Tamirat, N., & Tadele, S., 2023). Technical efficiency is a leading indicator, as such, measures ultimate performance of industries (Erena, O. et al., 2021; Nishanthini, A., & Nimalathasan, B., 2013). It helps the industries to underset and scale and scope of their activity and enables them to position and take appropriate actions to stay competitive in the market.

The term efficient in economics refers to the comparison between the observed input and output values and the optimum input and output values used in the production process (Karlaftis & Tsamboulas, 2012). It is the maximum outputs attainable from utilizing the available inputs (Munongo, S. & Chitungo, S. K., 2013). Production is efficient if it cannot improve any of its inputs or outputs without worsening some of its other inputs or outputs (Radam, A., et al, 2010). According to the same authors Efficiency can be increased by minimizing inputs while holding output constant or by maximizing output while holding inputs constant. Kumbhakar and Lovell (2003), also specified that technical efficiency is the ability to reduce the use of inputs to produce outputs or the ability to maximize output with existing input. Meanwhile, allocative efficiency reflects the firm's ability to use inputs at an optimal rate based on the cost and production technology (Erena, O. et al., 2021; Fikadie, D., 2022). These measures are combined to provide a measure of the total economic efficiency (Jofree, A. et al., 2021).

Among the fundamental economic problems that faces less developed countries, including Ethiopia, are their economies' backwardness and lack of efficient resources utilization to support their desire and drive (Bekele, T., & Belay, K., 2007). It is widely stated that technical inefficiency challenging the industrial sectors of the countries including wood industries (Erena, O. et al., 2021). According to Abuka (2005) Efficiency levels vary between industries and over time within the same industry. In Ethiopia there are limited studies on the technical efficiencies of

wood-based industries (Andaregie et al., 2020; Fikadie, D., 2022). Because of this, the country is not getting the expected benefits from the sector, and it has forced the country to import wood and wood products using a higher foreign currency (Kaba, G. et al., 2018; Girma, G., & Abate, T., 2021). In this regard, we want to evaluate the technical efficiency, of the Ethiopian wood industries of the country as well as to pinpoint the elements influencing their efficiency. The objective of this study was to analyze the technical efficiency of wood furniture firms in Ethiopian selected cities. Two analyses are involved, the first analysis determines the level of technical efficiency, and the second analysis identifies the determinants of technical inefficiency among the firms studied. The paper is organized in subsequent section, which discusses the research methods, data sources, and model specification; the following section analyses the results of the survey; and the last section provides the conclusions and the implications of the study.

2. Literature Review

2.1. Wood-based industries in Ethiopia

Wood-based industries in Ethiopia encompass various sectors such as sawmilling, furniture production, and other wood processing such as ply wood, chip wood, pulp and paper, veneer fiber board, and fuel wood which includes charcoal production. These industries utilize the abundant forest resources in the country plays a significant role in Ethiopia's economy, contributing to both employment and economic growth (Banaś, J. et al., 2021). Ethiopia is endowed with abundant forest resources, providing a solid foundation for various wood-based industries.

Sawmills in Ethiopia process logs into lumber for construction, furniture making, and other applications. Additionally, plywood manufacturing plants produce plywood sheets used in construction, furniture, and packaging industries. According to difrent litratures, the wood processing industry contributes significantly to the country's GDP and employment rate (Alem, S., 2016). Furniture manufacturing is a prominent sector within Ethiopia's wood-based industries (Tafesse, A. et al., 2016). Numerous furniture factories across the country produce a wide range of furniture items for domestic consumption (Birhan, G., 2014). This industry not only utilizes locally sourced wood but also creates employment opportunities for skilled artisans and craftsmen. Many scholars, indicating the sector's importance in the country's industrial development (Ethiopian Investment Commission, (Birhan, G., 2014; Tafesse, A. et al., 2016; Kaba, G. et al, 2022).

Ethiopia has a developing paper and pulp industry that relies on wood as its primary raw material. Paper mills produce various paper products such as printing paper, packaging materials, and tissue paper. Additionally, the pulp industry processes wood fibers to manufacture pulp, which serves as a raw material for paper production. The Ethiopian Ministry of Environment, Forest, and Climate Change outlines government efforts to support sustainable forestry practices to meet the raw material demands of the paper and pulp industry (MEFCC, 2017).

While not a sustainable practice, charcoal production remains prevalent in Ethiopia, particularly in rural areas. Charcoal is derived from wood through a carbonization process and is widely used as a household fuel source for cooking and heating. However, efforts are underway to promote sustainable alternatives to charcoal production to mitigate deforestation and environmental degradation. Various environmental organizations emphasize the need for sustainable forest management practices to address the adverse impacts of charcoal production on Ethiopia's forests (Sori, G. K. et al, 2023).

2.2. Technical efficiency of wood-based industries.

Efficiency in wood-based industries encompasses various dimensions, including technical efficiency. Technical efficiency in wood-based industries refers to the ability of these industries to produce maximum output from a given set of inputs, utilizing available technology and resources optimally (Kumbhakar and Lovell, 2003). It essentially measures how well these industries convert inputs such as raw materials, labor, and capital into outputs like lumber, paper products, or furniture (Tamirat, N., & Tadele, S., 2023).

Technical efficiency serves as a yardstick to evaluate the performance of wood-based industries against industry standards or competitors. It helps identify areas where resources are being underutilized or inefficiently allocated, enabling better resource management (Jofree, A. et al., 2021). Understanding technical efficiency aids in strategic planning, such as investment decisions, process improvements, or technology adoption (Munongo, S., & Chitungo, S. K., 2013).

Technical efficiency is commonly measured using various econometric techniques, with the most prevalent being Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). These methods assess the efficiency of wood-based industries by comparing their actual output to the maximum possible output given their inputs (Hailu, K. B., & Tanaka, M., 2015). Any output level below the maximum output level implies that firms are to some extent technically inefficient (Sleuwaegen, L., & Goedhuys, M., 2003). The efficiency scores generated by these analyses provide insights into the relative performance of different firms or industries.

Several factors influence the technical efficiency of wood-based industries, for instance: Adoption of modern machinery, automation, and innovative production techniques can enhance efficiency. Well-trained and skilled labor

can contribute to higher productivity and efficiency (Leza, T. et al., 2016). Availability and quality of timber resources significantly impact the efficiency of wood-based industries (Tafesse, A. 2016). Regulatory environment such as Compliance with environmental regulations, safety standards, and other legal requirements can affect operational efficiency.

3. Materials and Methods

3.1. Materials

The study was conducted in four (4) major cities of Ethiopia: - Addis Ababa, Hawassa, Jima and Bahir Dar. To achieve the intended objectives of this study, a cross-sectional survey approaches that includes both qualitative and quantitative elements was employed. Accordingly, from Addis Ababa 47, Jima 43, Bahir Dar 39, and Hawassa 41 a total of 170 furniture industries are determined and included in the study. Both primary and secondary data were used to get the relevant and necessary information.

3.2. Methods

Before collecting primary data, the reconnaissance survey was first gathered on availability of furniture industries in the selected sub-cities. And then a survey was carried out in different furniture factories found in the selected major cities. To collect primary data structured and semi structured questionnaires were developed in advance and the researchers used an interview guide to collect relevant information. This involved asking for the monthly and annual costs and the revenues from the sale of the products, types of machinery, sources of resource and their usages, market linkages and challenges during production and after production. Interviews were used because it is easy to fully get information in the shortest time possible.

In addition to primary data, secondary data was obtained through review of different documents and reports. The documents containing the expenditures and revenues of the business, firms' potential and profiles, resource availability and utilization characteristics were reviewed. These included the official reports, thesis, and dissertations, textbooks, manuals, and different journals. Some data in furniture workshops like types of machinery available in furniture workshops, species of timbers, production conditions and areas and others were collected through observation. These were done with a piece of paper to note down observed issues.

the collected data was encoded into the computer and edited and cleaned before analysis. Both descriptive and inferential or econometric methods of data analysis were utilized. The descriptive statistics such as sum values, means, standard deviations, and minimum and maxim values were calculated. The results were presented in the table and figure forms.

A production frontier represents the maximum amount of output that can be produced given a set of inputs. Since most firms typically fall below this output, the deviation from the maximum output is the measure of inefficiency and is the focus of our empirical work. In estimating the technical efficiency level of firms, one should further investigate the relationship between the efficiency determinant variables and technical efficiency of individual firms. To do so, the study pursues a two-stage estimation procedure. In the first stage, we estimate the efficiency levels of each firm. In the second stage, we run a regression of the estimated technical efficiency level of firms, that is to observe the relationship between the determinant variables and technical efficiency. The effect of each relevant controlled variable was analyzed using the maximum likely hood estimation method. A stochastic frontier model used in this study expressed as the following:

$$lnY_i = B_0 + \sum_{j=1}^{k} B_j lnX_{ij} + \epsilon_i$$

Where:

ln = denotes the natural logarithm.

i = represent the ith industry in the sample,

Y_i = represents output of the ith industry (Qt),

$B_0, B_1, \ldots, B_k$ are the parameters to be estimated

X_{ij} = refers to the inputs used in the ith industry

ϵ_i= vi-ui which is the residual random term composed of two elements vi and ui.

The vi is a symmetric component and permits a random variation in output due to different factors. The ui captures inefficiency in the production process.

4. Results

Most of the surveyed wood industries/ workshops104 (61.2%) are share companies; 35 (20.6%) sole proprietorships; and 29 (17.1%) Private limited companies. According to the central statistical authority, manufacturing industries including wood industries, are classified into 3 groups: namely, large, medium, small scale, and cottage and handicraft industry. The classification is based on the number of persons engaged in manufacturing and the level of means of production in each establishment. Accordingly, the following scales are referred to the classification of enterprises in the Ethiopian context. Medium Scale Manufacturing, engaging 10 or more persons and using power-driven machines; Small Scale Manufacturing engaging less than 10 Persons and use power-driven machines and Cottage/Handicraft Manufacturing performing their activities by hand (i.e., using non-power-driven machines). For this study most industries 129 (75.9%) were small scale while 41 (24.1%) were medium scale furniture workshops. The third category Cottage/Handicraft were not included in this study (Table 1).

Table 1. Industry ‘s profile

Description		Frequency	Percent
Industry's ownership type	Sole proprietorship	35	20.0
	Private limited company	29	16.6
	Share company	104	59.4
	other	2	1.1
Furniture industry types	Small scale	129	75.9
	Medium scale	41	24.1
Number of days worked in the wood industry per week	Three days	2	1.2
	Four days	1	0.6
	Five days	15	8.8
	Six days	142	83.5
	Seven days	10	5.9
Experience of industries in furniture manufacturing	1 -10	96	56.5
	11.00-20	58	34.1
	21.00-36	16	9.4

Source: Research Data (2023)

As expected, the technical efficiency and effectiveness of Ethiopia's wood industries is lower than expected. Out of a total of 170 (100%), about 149 (87.6 %) of the furniture workshops are technically inefficient (their technical efficiency status is very low) (Table 2). Only 18 (10.6%) are technically efficient (Table 2).

Table 2. Sample furniture industries (workshops) by technical efficiency status.

Technical efficiency status	Frequency	Percent	Cumulative Percent
Technical inefficiency	149	87.6	87.6
Technical efficiency	18	10.6	98.2
Total	167	98.2	100
Missed System	3	1.8	
Total	170	100.0	

Source: Research Data (2023)

There is variation in the level of efficiency among the cities. In Addis Ababa, the average industry efficiency is slightly higher than in Bahir Dar and Hawassa. Jima City's average efficiency is lower than that of other cities. The data of technical efficiency of the industries in different cities can be seen in Table 3.

Table 3. The technical efficiency of the industries in different cities

Name of cities	Mean efficiency	Mean inefficiency	No. of workshops
Addis Ababa	0.0283	0.234	47
Bahir Dar	0.0276	0.228	39
Hawasa	0.0281	0.232	40
Jimma	0.022	0.182	41
Total	0.106	0.876	167

Source: Research Data (2023)

Most respondents in wood industries agreed that the efficiency is low because they are not qualified and efficient to use the resources, they get to produce the products they want at the required level and quantity for various reasons. As mentioned from respondents the workers engaged in the work are not professionally trained, the machines and equipment they work on are not modern, the production and sales area are not convenient, the lack and quality of raw materials, the lack of sufficient capital and credit, the lack of market connections the main reasons. Additionally, some of them mention that inflation is the other problem. So, the government needs to consider rules and regulations on how to improve the overall inflation in the country.

Determinant of technical efficiency

Several factors account for industries technical inefficiency that had impact on furniture producers' productivity. Accordingly, the negative and significant coefficients of Lack of Working and selling place, Training, lack of modern machineries and tools or usage of outdated machineries, less education level of employees or producers indicate that improving these factors contribute to reducing technical efficiency. Whereas the positive and significant variable such as access to production inputs, end products diversification, Inflation and Credit affect the technical efficiency positively that is increases in the magnitude of these factors aggravate the implications of significant variables on the technical efficiency of furniture industries in the selected study areas were discussed below in Table 4.

Table 4. Maximum-likelihood estimates of technical inefficiency determinants.

Variables	Coefficients	SE	Z- value
Constant	1.039***	0.332	3.13
Lack of Working and selling place	-0.006**	0.003	-2.01
Training	-0.110*	0.060	-1.95
Production inputs	0.188***	0.043	3.83
Machineries and tools	-0.409***	0.092	-4.44
Education level of employee	-0 .709***	0.095	-7.46
capital	0.002	0.005	0.40
Size of the industry	-0 .061	0.041	-1.48
Owner ship	0.079	0.050	1.58
Products diversification	0.07**	0.016	3.39
Inflation	-0.268	0.049	-0.82
Credit	0 .523**	0.244	2.14
Log likelihood	-52.16		
Total sample size	170		

Source: Research Data (2023)

a. Lack of working and selling place

Convenient working environments and excellent selling locations are essential for industries to be productive and effective. Businesses cannot use their time, labor, and resources very effectively and efficiently if the locations where their products are produced and sold are inconvenient, nor can they sell their goods on schedule for prices that are fair and profitable. In this study as it was predicted, working, and selling locations had an adverse effect on technical efficiency at the 5% level of significance. This indicates that industries that create goods in inconvenient locations and sell them in uncomfortable places are technically less efficient and profitable than industries that have comparably more convenient production and selling locations. This in line with the study from Le, V., & Harvie, C. (2010) that location, and government assistances are significantly affecting technical efficiency of a firm.

b. Lack of Training

Training is an important tool in building the managerial capacity of industries. workers those gets training related to furniture production, lumber utilization practices, and marketing or any related woodworking training are hypothesized to be more efficient than those who did not receive training. Training is different from education in that it is on-the-job training whether employees are educated or not. It is important because it could improve the workers' skills regarding production practices, management, and related aspects. The workers in the study areas received training even for a few days mainly on furniture production practices, utilization alternative timber species and kaizen. The coefficient of training was negative and significant in the technical efficiency model of furniture

production at 10% level of significance. In other words, having training determined technical efficiency positively and significantly in furniture production. This implied that technical inefficiency effect decreases with workers having training. It may also be concluded that workers with training tended to have higher efficiency effects than workers without training. That is, workers with training were technically more efficient than workers without training. This is in line with the study done by Leza, T. et al., (2016) that training was significantly and positively affect technical efficiency level of micro and small enterprise in Ethiopia, Wolaita zone.

c. Availability of production inputs (raw materials)

It is hypothesized industries with better access to inputs or better available inputs are more productive and efficient than their competitors. The result shows that the availability of input has been determined to have a positive and significant effect (at the 1% level of significance) on industries' technical efficiency. In other words, Shortage and lack of quality raw materials has negative effect on the efficiency of wood industries. This study in line with many studies in Ethiopian firms for instance Tafesse, A. et al., (2016) revealed that the major problems for small and medium scale furniture manufacturing in Wolaita Sodo, Ethiopia is lack of sufficient a quality local raw material in the local market. Another study caried out in Malaysia by Saleh and Ndubisi, found that a low level of productivity and input quality may attribute to low levels of value added in small scale industries, which further affects the level of optimum efficiency in the production process.

d. Lack of education

Education enhances the achievement and utilization of information on improved technology by industries. In this study, education measured in grade (class level) of formal schooling; as expected, the sign of education had negative effect on technical inefficiency at 1% level of significance. This implies that less educated employees are not technically efficient than those that have relatively more education. This could be because educated workers could use information from various sources, interpret drawings and can apply the new information and technologies in their workshops that would increase output. In general, more educated employees were able to perceive, interpret and respond to new information and adopt improved technologies much faster than their counterparts.

e. Credit

It is an important element in industrial production systems. It allows furniture producers to satisfy their cash needs. Amount of credit increases industries' efficiency because it temporarily solves shortage of liquidity/working capital. In this study, amount of credit was hypothesized in such a way that industries who get more amount of credit from either formal or informal sources were expected to be more efficient than those who get less amount of credit. In this study, the amount of credit affected technical efficiency of furniture industries positively and significantly at 5% level of significance. This implies that credit availability shifts the cash constraint outwards and thus enables industries to make quality, the amount needed and timely purchases of inputs that they cannot afford otherwise from their own resources and enhances the use of industrial inputs that leads to more efficiency. The empirical studies conducted by Ahmed, M. H. et al., (2014) found a positive and significant relationship between credit and farmers' technical efficiency which was in line with this study.

f. Experience

The industry's experience in manufacturing can be approximated by looking at the age and length of its establishment. According to the findings, efficiency was positively influenced by the industries' experience at a 5% level of significance. This implied that businesses engaged in the production of furniture for a longer period were technically more efficient than those that did so for a shorter period. The cause of this may be that workers in the industries gain more skillfulness as they continue to work on the manufacturing process over time because of their accumulated production experiences. Additionally, gaining more production experience helps one understand the value and complexity of making effective production decisions, such as the efficient use of input. This outcome was in line with the arguments made by Mbusya, E. W., (2019) that the greater number of years a firm's operators, the more it enhances technical efficiency. According to this argument Industries are likely to become more knowledgeable, skilled, and physically capable as they become more established.

g. Diversified products

It is hypothesized that firms engaged in production of diversified products are more efficient than their counterparts. Besides for commercialization, it is used for risk minimization during market failure. The result also shows that end products diversification has a positive and significant effect on industries' efficiency (at 5% level of significance). This is due to the reason that firms engaged in the production of different furniture are more efficient in allocating their resources like labor, lumber, and other (like paints, varnish, nails, glue, etc.) resources without waste than their counterparts.

5. Discussion on Challenges Observed in Furniture Industries

Most employees in Ethiopia's furniture industry have never had formal or on-the-job training, both prior to and following their employment in industries. Along with working with outdated tools and machinery, they lack the skills to use them appropriately. The wood industries have indicated that one of their main problems is inconvenient locations for their products' manufacturing and selling places. Respondents in all surveyed city who participated in the data gathering process identified the primary obstacles confronting the wood industries as being a scarcity of raw materials and worries about their quality, in addition to a lack of capital, credit, and market connections. And there's general inflation as well. Furthermore, the inability to maintain quality standards and their restricted capacity for mass production were also mentioned by respondents in the wood industries in the research areas as issues. A lack of technical know-how to run modern machinery to produce modern goods, the high cost of raw materials, and a restricted capacity for large-scale production were some of these challenges. The growing number of challenges mentioned above might contribute to the low level of efficiency among the Ethiopia's wood industries.

6. Conclusion

Technical efficiency and effectiveness are essential to contribute to the improvement and development of industries and to the country's economy. Technical efficiency is the ability to produce higher and better output using necessary inputs or increase profitability by producing desired output with fewer inputs. Study indicates that the industries in Ethiopia, including the wood industry, are very low in profitability and efficiency. As a result, the country is not getting the benefits it deserves from the sector, and it has forced the country to import wood and wood products using a higher foreign exchange rate.

Therefore, it is very important to check the technical efficiency of the wood industry and if it is low, to identify the reasons and suggest the right direction, so a project has been designed and researched. In the study, information was collected from a total of one hundred and seventy (170) industries from four cities (Addis Ababa, Hawassa, Jimma and Bahir Dar). The collected data were analyzed, and the following indicative results were obtained. As expected, the technical efficiency and effectiveness of Ethiopia's wood industries is lower than expected. Among 170 industries, 87.6% lack technical efficiency and effectiveness.

The reasons for this are that the workers engaged in the work are not professionally trained, the machines and equipment they work on are not modern, the production and sales area is not convenient, the lack and quality of raw materials, the lack of sufficient capital and credit, the lack of market connections, the lack of technical efficiency and effectiveness, and the lack of profitability. Therefore, to improve the technical efficiency and profitability of the industries, it is better to have continuous vocational training, loan support so that they can get and use better machines, as well as convenient manufacturing, product display and sales, improving and facilitating market linkages. Policy makers have consistently looked for the optimal combination of measures to improve the productivity, profitability, and efficiency of the wood industries, and consequently, their contribution to the sector's competitiveness and the growth of the country's economy.

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