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TECHNICAL EFFICIENCY OF THE ETHIOPIAN GRAIN MILL PRODUCTS MANUFACTURING INDUSTRY

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Manufacturing firms, Output, Ownership status, Production function, Raw materials, Stochastic frontier, Technical efficiency

Abstract
This study focuses on the estimation of technical efficiency of firms and the identification of the determinants of technical efficiency in the Ethiopian grain mill products manufacturing industry. A stochastic frontier production function model was estimated and the results indicate that technical efficiency levels of firms differ profoundly. Firm size and existence of book of accounts were positively related to the technical efficiency level of firms whereas higher number of products and byproducts was found to have an adverse impact on firms' technical efficiency level. It was also found that publicly owned enterprises are less technically efficient than privately owned ones.

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Ⅰ. Introduction

One of the basic economic problems that faces less developed countries of today, of which Ethiopia is one, is the backwardness of their economies on one hand and the scarcity of resources to match their desire and drive on the other. It is widely asserted that technical inefficiency plagues the industrial sectors of these countries (Tybout, 1990). Gezahegn (1987) pointed to the fact that efficiency is a major problem in Ethiopia. In the country's manufacturing sector, capacity utilization has long been a problem and there are grounds for suspecting that many enterprises are more capital intensive than efficient choice of technique would warrant. Likewise, Pickett (1991) underlined that the industrial sector of Ethiopia has not been generally efficient. Given this state of affairs, there is considerable interest in documenting the patterns and magnitudes of these problems, so that appropriate policies can be designed.

The Ethiopian manufacturing sector is still backward and its contribution to GDP is probably the lowest in the world (3% as compared to 27% in low-income countries and 13% in low-income countries excluding China) (Befekadu and Berhanu, 1999). Most of the manufacturing establishments are concentrated in Addis Ababa. More precisely, about 64% of the large and medium scale manufacturing establishments operating in the country in the year 1999/2000 were located in Addis Ababa (CSA, 2001).

The Ethiopian manufacturing sector is dominated by food products and beverages manufacturing industries. In 1999/2000, the latter made up about 30 percent of the establishments in the manufacturing sector (CSA, 2001). 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 and Berhanu, 1999). In 1999/2000, grain mill products manufacturing firms (GMPMF) contributed about 21 percent of the manufacture of food products and beverages industrial group (CSA, 2001).

The GMPMFs can play a pivotal role in the economic development endeavor of the country. Apart from the direct benefits they bring to the economy through the creation of employment opportunities and the saving of hard currency, these firms use agricultural products, i.e. wheat and other grains as their raw material input. The linkage, resulting from the expansion of these firms, will therefore have a significant positive impact on the development of the agricultural sector and thereby serve as a stimulus for the development of the whole economy.

Under the military government, the great majority of the GMPMFs were state owned. The firms were operating under a highly centralized system of management whereby type and level of production and prices of products were determined through central planning. Consequently, there were no motivations for producers to improve their efficiency level. Since the launching of a new market oriented economic policy in 1992, the quota system, the provision of subsidies, and the price control mechanisms have been lifted. The various bureaucratic hurdles, which had been constraining the smooth operations of producers, were removed and a conducive investment climate was created in the country. By taking advantage of this situation, a large number of privately owned GMPMFs have been established and others are on the pipeline.

Though it is encouraging to have increased investments on new and improved technologies, in a poor country like Ethiopia, where resources are scarce, an equally important issue should be to promote technical efficiency at the firm level under the existing technology. Inefficiency is costly both to the producing units and to the society at large. Therefore, identifying the extent of inefficiency and the factors that contribute to it are of paramount importance. Such information is useful for formulating appropriate policies for reducing the level of technical inefficiency (Huang and Bagi, 1984). A study like this one is thus justified because of its importance in avoiding the redundancy of efforts and the wastage of resources.

Technical efficiency may be defined as 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. In other words, technical efficiency can be described 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.

The specific objectives of this study are to estimate the individual technical efficiency of firms and to identify the determinants of technical efficiency in the Ethiopian grain mill products manufacturing industry.

The rest of the paper is organized as follows: A brief presentation of the sampling and data collection procedure is made in part two. Part three discusses the econometric models and estimation procedures used in the study. Part four presents and discusses the results of the study. The final part concludes and draws appropriate recommendations.

II. Sampling and Data Collection

The study covers those enterprises which utilize grains as their major raw material input to produce final outputs like flour, biscuits, spaghetti, macaroni, etc. The study is confined to those establishments, which engage 10 persons or more, and covers both private and public enterprises in all regions of the country, where GMPMFs are found.

1. Sampling

Results of a survey made by the Central Statistical Authority (CSA), on medium and large scale manufacturing industries, were used in this study to determine the sample size and select the manufacturing establishments to be included in the sample. According to this survey, Ethiopia had fifty grain mill products manufacturing establishments distributed across six regions of the country[1] at the end of the 1999/2000 fiscal year.

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[1] With the change of government in 1991, the country was divided into 9 semi-autonomous administrative regions, one federal capital (Addis Ababa), and one special administrative division (Dire Dawa) on the basis of ethnic, linguistic, and cultural identity. The nine autonomous regions include the Afar National Regional State (AFNRS), the Amhara National Regional State (ANRS), the Benshangul Gumuz National Regional State (BGNRS), the Gambela Peoples National Regional State (GPNRS), the Harari People National Regional State (HPNRS), the Oromiya National Regional State (ONRS), the Somali National Regional State (SNRS), the Southern Nations Nationalities and Peoples Regional State (SNNPRS), and the Tigray National Regional State (TNRS).

This study covered 90 % of the GMPMFs in the country. A combination of purposive and random sampling techniques was used to draw the sample. To ensure a reasonable countrywide coverage, all GMPMFs, which are located in regions where the total number of establishments is less than or equal to three, were included in the sample. Accordingly, nine firms from ANRS (3), TNRS (2), SNNPRS (2), and Dire Dawa Administrative Council (2) were automatically included in the study.

The remaining 41 GMPMFs were grouped to three categories by the number of persons they employed (10-19, 20-49, and over 50). Thereafter, firms were selected randomly on the basis of the proportion of firms in each category. As a result, the total sample size was 45 (90 percent of the GMPMFs in the country)[2]. Privately owned firms constituted 80 percent of the sample (36) while the remaining (20 percent or 9 firms) were publicly owned. Table 2 shows the distribution of sample GMPMFs by type of ownership and region.

TABLE 1. Regional Distribution of GMPMFs in Ethiopia, by Size of Persons Employed (1999/2000)

Number of persons employed	Number of GMPMFs by region						
	Addis Ababa	ANRS	Dire Dawa	ONRS	SNNPRS	TNRS	Total
10-19	6	1	1	6	-	-	14
20-49	6	1	-	6	-	-	13
50 and above	8	1	1	9	2	2	23
Total	20	3	2	21	2	2	50

Source: (CSA, unpublished information)

[2] The initial plan was to carry out a complete census of all the GMPMFs in the country. However, the shortage of financial resources required to undertake the survey and time constraint forced the researchers to resort to the idea of taking a random sample of 17 of the 20 firms in Addis Ababa and 19 of the 21 firms in the ONRS with the firm belief that the information generated from the survey would represent fairly the performance of GMPMFs in the country.

TABLE 2. Distribution of GMPMFs Included in the Sample by Region, Type of Ownership and Number of Employees

Number of persons employed	Number of GMPMFs																				
	Addis Ababa			ANRS			Dire Dawa			ONRS			SNNPRS			TNRS			Total		
	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total
10−19	-	5	5	-	1	1	-	1	1	-	6	6	-	-	-	-	-	-	-	13	13
20−49	-	5	5	-	1	1	-	-	-	-	5	5	-	-	-	-	-	-	-	11	11
50 and above	3	4	7	-	1	1	1	-	1	3	5	8	1	1	2	1	1	2	9	12	21
Total	3	14	17	-	3	3	1	1	2	3	16	19	1	1	2	1	1	2	9	36	45

2. Data Collection

A structured questionnaire was designed, pre-tested on selected firms, and refined before it was ready for data collection. With the exception of three establishments which were either temporarily closed during the data collection period or their owners refused to give the required information, the questionnaire was administered to all the firms included in the sample[3]. Consequently, the data used in this study were collected from 42 firms.

The collected data and information pertain to the 1999/2000 production year. The data collection was conducted by visiting each enterprise in the sample. Managers (owners as the case may be) by themselves or in collaboration with finance and/or administration officers furnished the required information. Accounting, performance, and audit reports of the enterprises were proved to be valuable sources of information for this study.

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[3] Data were not collected from three privately owned firms (one each from Addis Ababa, ANRS and ONRS).

III. Model Specification and Estimation Procedure

1. The Model

A stochastic frontier production function model was used to evaluate the technical efficiency of the sampled GMPMFs. A Cobb-Douglas functional form is chosen because it has been very popular in applied work and it fits well even for smaller data sets (Croppenstedt and Abbi, 1996). The Cobb-Douglas production function has been the function of choice for production analysis (both theoretical and empirical) due to its elegance, simplicity, and ease of interpretation and estimation. It is admittedly restrictive in that it imposes restrictions including unitary elasticity of substitution and fixed production elasticities (Capalbo and Antle, 1988; Saito, 1994). Taylor *et al.* (1986) argued that as long as interest rests on efficiency measurements, not on the analysis of the general structure of production technology, the Cobb-Douglas production function provides an adequate representation of the production technology. Moreover, Kopp and Smith (1980), one of the very few studies examining the impact of functional form on efficiency, concluded that functional specification has a discernible but rather small impact on estimated efficiency. That is why the Cobb-Douglas functional form has been widely used in efficiency analysis both in developing and developed countries.

The model is specified as follows:

$$\ln\left(Y_i\right) = \beta_0 + \sum_{j=1}^{k} \beta_j \ln X_i + v_i - u_i \qquad (1)$$

Where:

i = 1,2,....N

j = 1, 2,....k

Yi = output for the ith firm.

$\beta = (\beta_0, \beta_1, \cdots, \beta_k)$ is a (k+1) column vector of unknown parameters to be estimated.

X_i = a (k + 1) row vector whose 1^{st} element is "1" and the remaining elements are the logarithms of the k input quantities used by the i^{th} firm.

u_i is a non-negative random variable, which captures the technical inefficiency in production of firms in the industry involved, and it is assumed to be the result of factors, which come under the control of the decision unit in the firm. For the function to remain that of a maximum output, i.e. frontier function, the inefficiency element (u_i) should always take negative values. For convenience, ui is subtracted from the function and is assumed to be non-negative (Schmidt, 1976).

v_i is the familiar disturbance term which captures those factors that are beyond the control of the decision unit. This component of the error term makes the production frontier stochastic and, therefore, allows the frontier to vary over time for the same firm.

The v_i s are assumed to be independent and identically distributed normal variables with mean zero and constant variance, σ^2_v, independent of the u_i s, which are assumed to be independent and identically distributed half-normal random variables (Coelli *et al.*, 1998).

The following variables were used in the estimation of the stochastic frontier production function model (equation 1).

Output (Y_i): In this study, total value of output, in Birr, is used to represent the dependent variable in the model[4]. Measuring output in value terms makes it possible to aggregately measure the outputs of firms, which produce more than one kind of products (such as different qualities of flour, spaghetti, macaroni, biscuits, etc.).

Capital input (K_i): Following Huang and Bagi (1984), the sum of depreciation, interest cost on fixed investment, repair and maintenance cost, and operating expenses related to machinery was used in this study, as a proxy measure of the capital input used in the production process.

Labor input (L_i): In empirical studies, a simple addition of a man-hour disguises the heterogeneous nature of labor input (Admit, 1997). However, a review of literature reveals that it is not uncommon to use unweighted measures of labor flows, like total number of employees, in empirical studies (Meeusen and Broeck, 1977; Apezteguia and Garet, 1997). In this study, total amount of salary and other employee benefits paid to employees

[4] Birr is the Ethiopian national currency. The exchange rate is currently determined by inter-bank exchange of currencies and it is around 1 US dollar=8.7 birr.

in the given production year was used to measure the labor input, because it is the simplest mechanism available to make labor homogeneous.

Raw material input (RM_i): Total value of grains consumed in the production year considered, measured in Birr, is used to measure the raw material input used in the production process.

2. Estimation of the model

If Ordinary Least Squares (OLS) estimation procedure is used to estimate the parameters of the model, it is possible to get consistent estimators for all the parameters except the intercept term. Since the mean of (v - u) is not zero by assumption, the estimator of the intercept term will be biased. However, a consistent estimator of the intercept can be formed by using Corrected Ordinary Least Squares (COLS), which involves adjusting the OLS intercept by the mean of u.

In addition to the COLS method, one can also adopt the more efficient maximum likelihood (ML) approach (Sharif and Dar, 1996). The COLS approach is not as computationally demanding as the ML method. However, the ML estimation is asymptotically more efficient than the COLS estimator and empirical investigations suggested that the ML estimation is significantly better than the COLS estimator, when the contribution of the technical inefficiency effects to the total variance term is large[5]. Given this, and the availability of automated ML routines, the ML estimation should be used in preference of the COLS estimator whenever possible (Coelli *et al.*, 1998)

In this study, ML estimation procedure is used to estimate the stochastic production function model described in equation (1). To use ML estimation procedure, the assumptions made about the distributions of the error components u and v should be respected. It is assumed that u_i s are independently and identically distributed half-normal random variables with mean zero and variance σ^2[6]. While v_i s are assumed to be independent and

[5] It should also be noted that while using COLS some of the residuals may have 'wrong' signs so that the corresponding observations end up above the estimated production frontier. This makes the COLS frontier a somewhat awkward basis for computing the technical efficiency of individual observations.

identically distributed normal random variables with mean zero and constant variance σ^2_v. ($v \sim (0, \sigma^2_v)$), independent of the u_i s.

By defining a parameter γ, which lies between zero and one and is equal to σ^2/σ^2_s, (where $\sigma^2_s = \sigma^2 + \sigma^2_v$), Battese and Cora (1977) showed that the log-likelihood function in terms of this parameterization is equal to:

$$\ln(L) = -\frac{N}{2}\ln(\Pi/2) - \frac{N}{2}\log(\sigma_s^2) + \sum_{i=1}^{N}\ln[1-\Phi(Z_i)] - \frac{1}{2\sigma_s^2}\sum_{i=1}^{N}(\ln Y_i - X_i\beta)^2 \quad (2)$$

Where:

$$Z_i = \frac{(\ln Y_i - X_i\beta)}{\sigma_s}\sqrt{\frac{\gamma}{1-\gamma}}$$

and $\Phi(\cdot)$ is the distribution function of the standard normal random variable.

The ML estimates of β, $\sigma^2 s$, and γ are obtained by finding the maximum of the log-likelihood function defined by equation (2). The ML estimators are consistent and asymptotically efficient (Coelli *et al.*, 1998).

A computer program called FRONTIER version 4.1 was used to obtain the ML estimates of this model.

3. Prediction of firm-level technical efficiency

After the estimates of the model parameters are found, the results are used to estimate the technical efficiency levels of each individual firm in the sample observation. The ratio of the observed output for the ith firm, relative to the potential output, defined by the frontier function, given the input vector Xi is used to define the technical efficiency of the ith firm:

$$TE_i = \frac{Y_i}{\exp(X_i\beta)} = \frac{\exp(X_i\beta - u_i)}{\exp(X_i\beta)} = \exp(-u_i) \quad (3)$$

6 This assumption ensures that the production frontier specifies maximum output levels for a given set of inputs and existing production technologies and that the outputs of individual firms in the sample lie on or beneath the frontier.

The technical inefficiency effect, u_i, is unobservable. Even if the true value of the parameter vector, β, in equation (3) was known, only the difference, $\varepsilon_i = v_i - u_i$, could be observed. The best predictor for u_i is its conditional expectation given the value of ε_i (Coelli, *et al.*, 1998).

$$E[\exp(-u_i)|\varepsilon_i] = \frac{1-\Phi(\sigma_{\wedge} + \gamma\varepsilon_i / \sigma_{\wedge})}{1-\Phi(\gamma\varepsilon_i / \sigma_{\wedge})} \exp(\gamma\varepsilon_i + \sigma_{\wedge}^2 / 2) \qquad (4)$$

where: $\sigma_A = \sqrt{\gamma(1-\gamma)\sigma_s^2}$; $\varepsilon_i = \ln Y_i - X_i \beta$, and $\Phi(\cdot)$ is the density function of a standard normal random variable.

4. Determinants of Inefficiency

Identifying efficiency levels for individual firms is not an end by itself. Once it is determined that some firms produce more than others using the same inputs, it is important to determine what causes this difference. A second stage analysis is conducted to identify the determinants of technical inefficiencies among the firms in the sample observation. The predicted efficiency measures obtained from the estimated stochastic frontier production function are regressed on a vector of firm-specific variables. A multiple linear regression model, which is specified below (equation 5), was used for this part of the study.

$$TE_i = \beta_0 + \beta_1 OWNERSTA_i + \beta_2 IMPRMIR_i + \beta_3 SIZE_i + \beta_4 DISTFRMS_i + \beta_5 RMSH_i + \beta_6 NPROD_i + \beta_7 BOOKACCT_i + \beta_8 FRMB_i + \beta_9 SPPSH_i + \varepsilon_i \qquad (5)$$

The dependent variable in equation (5) is TE_i. It represents the predicted technical efficiency level of the i^{th} firm obtained from the estimated stochastic frontier production function. ε_i is the disturbance term and Table 3 presents the variables that are hypothesized to affect technical efficiency level of individual firms.

Table 3: Description, Measurement, and a priori Expectations of the Variables Affecting Technical Efficiency Level of Individual Firms

Variable acronym	Description	Measurement	Expected signs
BOOKACCT	Book of accounts	Dichotomous: 1 for firms which maintain a complete book of accounts and a value zero otherwise	+
DISTFRMS	Average distance from major raw material sources	The average road distance, in kilometers, of the firm's home town from the towns where the firm mainly procures its raw materials	—
FRMB	Frequent machinery breakage	Dichotomous: 1 if the firm faced a problem of frequent machinery breakage in the production year considered, and a value zero otherwise	—
IMPRMIR	Ratio of the value imported raw materials to the total value of raw materials used	Total value, in birr, of raw material inputs imported divided by total value of raw materials used by the firm in the 1999/2000 production year	—
OWNERSTAT	Ownership status	Dichotomous: 1 if a firm is publicly owned, and a value zero otherwise.	—*
NPROD	Number of products and by-products	Total number of the different kinds of products and by-products produced by a firm.	—
RMSH	Raw material shortage	Dichotomous: 1 for firms that frequently faced shortage of raw materials in the production year considered and a value zero otherwise	—
SIZE	Size of the firm	The gross capital of a firm. To keep the variable at a manageable size, the gross capital is measured in 100,000 birr.	—
SPPSH	Spare part shortage	Dichotomous: 1 if the firm faced a problem of spare part shortage in the production year considered, and a value zero otherwise.	—

* It is widely believed that government bureaucracies reduce the flexibility of public enterprises in hiring, promoting and rewarding of outstanding employees and firing of unproductive ones. In some cases this leads to over manning and reduces efficiency in the public sector (ILO, 1982). Based on the above arguments, it is hypothesized that the variable **OWNERSTA** (ownership status) affects firm level technical efficiency negatively.

Ⅳ. Results and Discussion

Summary of the variables used in the estimation of the stochastic frontier production function model is presented in Table 4.

The ML (Maximum Likelihood) estimates of the coefficients of the specified stochastic production function model (equation 1) are depicted in Table 5[7]. All the estimated coefficients are statistically significant and have the expected positive signs.

TABLE 4. Summary Statistics of the Input and Output Variables (Birr)

Variable	Symbol	Mean	Max value	Min value	SD
Out put	Y	10,847,526	80,794,014	14,500	15,530,681
Raw material	RM	8,949,269	60,222,921	10,890	12,115,996
Capital	K	581,951	2,493,393	1,313	617,703.9
Labor	L	395,081	1,786,161	2,350	484,883

Source: survey results

TABLE 5. ML Estimates of the Stochastic Frontier Cobb-Douglas Production Function

Variable	Estimated coefficients	Standard error	t ratio
Constant	1.05	0.37	2.83***
Raw material	0.81	0.039	20.92***
Capital	0.09	0.04	1.786*
Labor	0.10	0.05	1.790*
σ^2	0.19	0.055	3.46***
γ	0.91	0.07	13***

*** = Significant at 1 percent level of probability
* = Significant at 10 percent level of probability

Source: Model output

7 Before proceeding with the estimation of the specified model, the variance inflation factor (VIF) technique was used to measure the degree of multicolinearity among the explanatory variables. The results of the computation show that there was no serious problem of multicolinearity among the input variables. Consequently, the specified model was estimated by including all the explanatory variables.

The γ estimate is very large (0.91) and its estimated standard error is low (0.07). These results indicate that much of the deviations from the frontier is due to the inefficiency effect (91%), u_i, rather than random noise.

Before proceeding to measure technical efficiency of the individual firms, it is imperative to test the existence of technical inefficiency among the sample firms. In order to determine whether or not there is technical inefficiency in the sample firms, a generalized one-sided likelihood ratio test was conducted. The generalized likelihood ratio test requires the estimation of the model under both the null and alternative hypotheses. The null hypothesis, H_0: $\gamma = 0$, states that the traditional production function is an adequate representation of the sample data, given the specification of Cobb-Douglas production function. This hypothesis implies that technical inefficiency effects, ui , are not present in the stochastic frontier production function model (equation 1). In other words, the hypothesis will help determine whether or not the parameters of the stochastic frontier production function and the traditional average (response) function differ significantly (Coelli *et al.*, 1998). The test statistics is calculated as:

$$LR = -2\{\ln[L(H_0)/L(H_1)]\} = -2\{\ln[L(H_0)] - \ln[L(H_1)]\} \quad (6)$$

Where $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the null and alternative hypotheses, H_0 and H_1 respectively. This test statistics is assumed to be asymptotically distributed as a chi-square random variable with degrees of freedom equal to the number of restrictions involved (in this case one). The calculated test statistic is found to be 9.18 (Output of the FRONT.41 Computer Program) which exceeds the 5 percent critical value 2.71. Consequently, the null hypothesis is rejected at 5 percent level of significance. This shows that the traditional average (response) function is not an adequate representation of the data and that the inefficiency effects, associated with technical inefficiency of production, are significant for the sample firms.

The maximum likelihood estimates of the Cobb-Douglas stochastic production function coefficients, which are presented in Table 4, are used to predict the technical efficiencies of the sample individual firms. The results indicate that technical efficiency levels of firms in the sample differ profoundly ranging from the smallest 18.98 percent to the highest 95.04 percent. The results further reveal that the mean technical efficiency for the sample firms is 75.6 percent. This proves the fact that there is a wide room for improvement. More precisely, on the average, output can be expanded by as much as 24.4 percent if appropriate measures are taken to improve technical efficiency. Table 6 clearly shows that about 5 percent of the sample firms have a technical efficiency level of less than 50 percent, whereas about 12 percent of them have a technical efficiency level of more than 90 percent.

While identifying a large shortfall in potential output is interesting by itself, for policy purposes it is crucial to isolate some of the determinants of technical efficiency (Croppenstedt and Abbi, 1996). For this reason, the multiple linear regression model, which was specified earlier (equation 5), was estimated. The estimated technical efficiency indices obtained from the estimated stochastic production function were used as the values of the dependent variable in this second stage regression. Table 7 presents the definition, units of measurement, and summary of the variables used in the second stage multiple regression analysis.

Results of the estimation of the model are depicted in Table 8. The results reveal that the variables specified in the model explain about 50 percent of the variation in the level of technical efficiency. The overall function is found to be statistically significant at 1 percent level of significance.

TABLE 6. Distribution of sample Firms by the degree of Technical Efficiency

Efficiency index	No of establishments	Percentage
< 50%	2	4.8
50 - 60%	2	4.8
60.01 - 70%	8	19.0
70.01 - 75%	5	11.9
75.01 - 80%	8	19.0
80.01 - 85%	9	21.4
85.01 - 90%	3	7.1
> 90%	5	11.9
Total	42	100

TABLE 7. Summary Statistics of the Multiple Regression Analysis Variables

Variables	Unit or type	% with a value 1	Mean
TE	Technical efficiency level of the individual firm expressed in percentage		75.6
OWNERSTA	Dummy, 1 if the firm is publicly owned and 0 otherwise	21.4	
IMPRMIR	Value of imported inputs divided by total value of raw materials (percentage)		9.6
SIZE	Gross capital divided by 100, 000 (Birr)		55.6
DISTFRMS	KM, average distance from raw material sources		212.1
NPROD	Number of products and byproducts the firm produces		3.1
BOOKACCT	Dummy, 1 if the firm maintains a complete book of account and 0 otherwise	64.3	
FRMB	Dummy, 1 if the firm faces a problem of frequent machinery breakage and 0 otherwise	10	
SPPSH	Dummy, 1 if the firm faces a problem of spare part shortage and 0 otherwise	14	
RMSH	Dummy, 1 if the firm faces a problem of raw material shortage and 0 otherwise	17	

Source: survey results

TABLE 8. Estimates of the Multiple Regression Model

Variable	Coefficient	Standard error	t ratio
CONSTANT	76.103	5.051	15.067***
OWNERSTA	-10.753	5.087	-2.114**
IMPRMIR	-0.066	0.094	-0.702
SIZE	0.099	0.041	2.415**
DISTFRMS	0.009	0.009	1
NPROD	-4.345	1.349	-3.222***
BOOKACCT	10.069	4.805	2.095**
FRMB	7.240	7.025	1.031
SPPSH	4.086	5.697	0.717
RMSH	3.571	5.126	0.697

*** = significant at 1 percent probability level
** = significant at 5 percent probability level
R^2 = 50.2%, Adjusted R^2 = 36.2%, $F_{9,32}$ = 3.584

Four explanatory variables are found to be statistically significant at less than or equal to 5 percent level of significance. In what follows the significant explanatory variables are discussed briefly.

The dummy variable OWNERSTAT is significant at 5 percent level of probability. This indicates that form of ownership of the GMPMFs is related to technical efficiency level. The variable has the expected negative sign, which signifies that privately owned and operated GMPMFs are more technically efficient than those, which are owned by the government. As noted earlier, restrictions in the decision making power of public enterprise managers and rigidity of government rules and regulations in employee administration and other enterprise activities, tend to decrease the relative speed and flexibility of responses of enterprises to market and other changes in the business environment. These factors seem to reduce the technical efficiency level of public manufacturing enterprises.

The variable SIZE is significant at 5 percent probability level. It has the expected positive sign indicating that the size of an enterprise is directly related to its technical efficiency level. Technical efficiency improves as the size of a firm increase. In other words, bigger firms are more efficient than the smaller ones. Apezteguia and Garet (1997) and Carter and Cubbage (1995) reported similar results in the Spanish agro-food industry and in the Southern US pulpwood harvesting industry, respectively. Relatively better financial capacity, better ability to attract and maintain skilled manpower and eligibility for credit of bigger firms seem to be instrumental in improving technical efficiency level.

As expected, the variable NPROD (number of products and by-products) assumes a negative sign and is significant at 1 percent probability level. The negative sign indicates that there is an inverse relationship between the number of products a firm produces and its technical efficiency level. This result suggests that firms could improve their technical efficiency level if they reduce the number of their products and specialize in few but selected products. It is relatively easier for a firm to plan, make a close follow up and necessary adjustments if it produces fewer products. As the number of products a firm produces increases, the type and complexities of production activities required at different production stages will increase. Given the limited number of available skilled manpower in manufacturing enterprises, this will divide the firm’s effort towards improving its technical efficiency, between different production lines instead of concentrating in the production of a selected few products.

The dummy variable BOOKACCT has the expected positive sign and is significant at 5 percent level of significance. This implies that maintaining a book of account is directly related to a firm's technical efficiency level. The result indicates that maintaining a book of account will help firms to improve their technical efficiency level. Firms, which keep a complete book of account, are in a better position to prudently plan and follow up the day-to-day operations of their production unit. This will help them improve their technical efficiency level by avoiding unnecessary wastage of resources.

Ⅴ. Conclusion and Recommendations

The results of the study confirm that the technical efficiency level of the sample firms varied from the smallest 18.9 percent to the highest 95 percent. The results further reveal that the mean technical efficiency level of the sample firms was 75.6 percent. This implies that output could be expanded by as much as 24.4 percent on average if appropriate measures are taken to improve technical efficiency. The analytical findings also show that 40.5 percent of the sampled GMPMFs were operating below the estimated industrial mean technical efficiency level. These results prove the fact that there is a wide room for improvement.

The results of the second stage analysis reveal that form of ownership, size of the firms, whether or not a firm maintained books of account, and the number of products and byproducts a firm produced were significant determinants of technical efficiency level of firms.

A close scrutiny of the results of the estimated multiple regression model reveals that size of the enterprise and the existence of books of account affected positively technical efficiency of firms while higher number of products and byproducts had an adverse impact on technical efficiency level. It was also found that publicly owned enterprises were less technically efficient than the private enterprises.

Based on the results of the study some recommendations are suggested to be addressed both at government as well as at firm levels. The GMPMFs which are owned and operated by the government were found to be less technically efficient than the privately owned ones. On the other hand, the government is in the process of privatizing unprofitable enterprises. It is, therefore, recommended that the government should speed up the privatization process and transfer the public GMPMFs into private hands. Books of accounts were found to be instrumental in improving a firm's technical efficiency level. A firm, which maintains a complete book of accounts, will be in a better position to plan and follow up the day-to-day operations of all its activities in a judicious manner. Consequently, firms are strongly advised to maintain a complete book of account. As it was evidenced by the results of the study, the size of a firm has an important bearing on its technical efficiency level. Bigger firms were found to be more technically efficient than the smaller ones. Consequently, it is preferred to have few larger firms, instead of many smaller ones, in order to promote the efficient utilization of resources in the future. Private entrepreneurs could join together to pool the necessary capital required for the establishment of these kinds of firms and the government should also gear its attention towards encouraging the development of big and modern GMPMFs and facilitate their financing arrangements. Results of the study also pointed out that increasing the number of products a firm produces will adversely affect its technical efficiency level. Based on this result it is recommended that firms should specialize in producing few but selected products.

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