

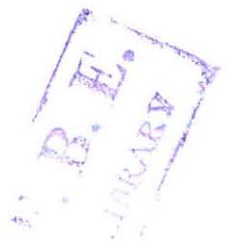
**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES**

**AN ANALYSIS OF ECONOMIC EFFICIENCY
DIFFERENCES BETWEEN PRIVATE AND PUBLIC
FOOD PROCESSING FIRMS IN ETHIOPIA:
A SWITCHING REGRESSION MODEL**

By

HAILEGEBRIEL YIRDAW YIGEZU

**JUNE 2009
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**A project submitted to the School of Graduate Studies of Addis Ababa
University in partial fulfillment of the requirements for the Degree of
Master of Arts in Economics**

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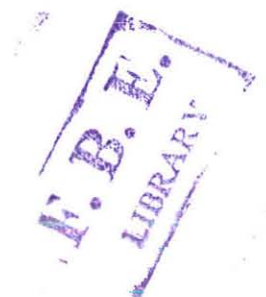
ACRONYMS AND ABBREVIATIONS

AE	Allocative Efficiency
CE	Cost Efficiency
CSA	Central Statistical Authority
DEA	Data Envelope Analysis
EE	Economic Efficiency
EEA	Ethiopian Economic Association
EEPA	Ethiopian Export Promotion Agency
GDP	Gross Domestic Product
NEC	Not Elsewhere Classified
TE	Technical Efficiency
UNIDO	United Nation Industrial Development Organization

Abstract

Technical, allocative and economic efficiency measures are derived for a sample of 73 food processing firms in Ethiopia. A switching regression model was used to examine potential selectivity bias for private and public owned firms. A three separated Stochastic Production Frontier (SPFs) and Cost functions corrected for selectivity bias were estimated for each group. The stochastic frontier Cobb Douglas production and cost function model was used to measure the firm-level efficiency differential between private and public owned food processing firms and to predict the firm level technical, economic and allocative efficiencies. The predicted technical efficiency and economic efficiency are the basis for estimating allocative efficiency of private and public firms under the study.

The result of the analysis indicate that presence of technical inefficiency and cost inefficiency effects in food processing firms in general and in the public food processing firms in particular, which realized by the significant estimated gamma coefficients and the generalized likelihood ratio test. The main results indicate that firms with private ownership show statistically higher average TE than those with public ownership. The estimated mean technical and economic efficiencies obtained from SPFs and cost function were higher for private food processing firms than their counterparts. Moreover the results indicate that mean technical efficiency levels of firms in the sector differ profoundly from the 56 percent 28 percent respectively for private and public firms. 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 44 and 72 percent if appropriate measures are taken to improve the technical efficiency. The impact of privatization on TE was analyzed and found positive and have significant effect on efficiency. Based on the results of the study, in order to promote efficient utilization of input resources, the government should speed up the privatization process and transfer the public firms in to private hands.



I. Introduction

Ethiopia's economy is heavily dependent on agriculture. It accounts for about half of GDP, 90% of exports, and 85% of total employment. Ethiopia stands third in the world and first in Sub-Saharan Africa in terms of the share of GDP that stems from agriculture (Block, 1999). Coffee generates 53% of the export revenues with *t'chat* second and other export commodities includes oilseeds, horticultural crops, livestock, and their products (EEPA, 2002).

Food manufacturers are firms that transform animal, vegetable, or marine material into intermediate or edible products (Connor and Schiek, 1997). As the dominant manufacturing sub-sector, the food processing industry includes 9 industrial groups consisting of 200 factories (26%) with a total paid-up capital of Birr 2.5 billion (44%) and 19,000 employees (20%) of the total share of the manufacturing sector. Comprising only 18% of the total number of food factories, the public food factories dominate the sub-sector with 83% of total paid-up capital, 76% of GVP and 71% of employment. Foreign capital in the sub-sector, on the other hand, constitutes only 5.3% (EEA, 2007).

The food factories are located in close proximity to major urban centers such as Addis Ababa, Nazareth and Dire Dawa. Product lines include frozen, chilled and canned meats; pasteurized milk, butter and cheese; canned and fresh fruits and vegetable products; crude and refined edible oil; flour and bakery products, including spaghetti and macaroni; animal feeds; and sugar and sugar confectioner.

The quality of these products are generally satisfactory, although the technology used tends to be largely old, with capacity utilization in the sub-sector averaging 58%.

Sugar processing; grain mill and bakery products industry; and meat, vegetable and fruit processing industries are the largest food industries, in that order. The sugar industry alone generates over 47% of the GVP and 35% of employment of the whole food-processing sub-sector (UNIDO, 2001).

Low level of investment, due to negligible domestic saving and limited external resource flows, hampered development efforts throughout the economy (UNIDO, 1991).

Consequently, the contribution of the manufacturing sector to gross domestic product is the lowest in the world (Befekadu and Berhanu, 1999/200).

The concept of efficiency is at the core of economic theory. The theory of production economics is concerned with optimization, and optimization implies efficiency (Baumol, 1977).The measurement of efficiency¹ has remained an area of important research both in developed and developing countries, especially in developing economies, where resources are meager and opportunities for developing and adopting better technologies are dwindling (Bedasa and Krishnamoorthy, 1997).

Promoting economic efficiency at firm level under the existing technology is very important to enhance the contributions of the sector to national economy. Actually, inefficiency is costly

¹ Technical, allocative and economic efficiency

both to the producing units and to the society at large. Hence, identifying the extent of inefficiency and the factors that contribute to it is of a paramount importance.

Such information is useful for formulating appropriate policies and for reducing the level of economic inefficiency (Huang and Bagi, 1984).

An empirical study pointed out that the industrial sector of Ethiopia has not been generally efficient and efficiency is a major problem of state owned industries in general and textile industries in particular in Ethiopia (Gezahegn ,1987, Picket 1991).

However, despite the critical importance of efficiency to the Ethiopian manufacturing industry in general, food processing industry in particular, there are hardly any studies of an analytical nature which examines the economic differences between private and public food processing firms.

The development of the food processing industry in Ethiopia has to be viewed in the context of the low level of development of the industrial sector in general and the manufacturing components of the sector in particular. In Ethiopia, the share of the industrial sector to GDP is a mere 11.2 %, compared to Ethiopia's subsistence agriculture which dominates the Ethiopian economy with a contribution of GDP of 44.8 %. Among industrial sectors ,the manufacturing sector ,at constant factor cost of 1980/81,contributed only 6.3% to GDP including large and medium manufacturing industry (CSA,2001).The large and medium scale food processing industry accounted for about 29% of the total gross value of production of the large and medium scale manufacturing industry(LMSM),constituting the largest share among this class of manufacturing industry in the country .

More significantly ,the relative contribution the large and medium scale food industry to the total value-added of the large and medium scale manufacturing sector is 38%(UNIDO,2001).The large and medium scale manufacturing industry is the most important group among manufacturing industries ,accounting for more than two-thirds of the gross value of the manufacturing sub- sector (EEA,1999/2000).These facts indicate that the food processing industry plays an important role in the relatively under developed industrial and/or manufacturing sector of the Ethiopian economy.

In spite of its potential positive contributions to the economy, the Ethiopian food processing industry is not well developed. The growing demand for processed products is not being satisfied with the current production level of domestic firms .To close the gap between the domestic demand for processed food and supply of processed food products, it is imperative to increase domestic production through enhancing efficiency.

Domestic production level may be increased by increasing the number of domestic firms or by increasing the capacity of the already existing firms. However, due to the scarcity of resources, which are necessary for establishing new enterprises, one should look for alternative and more plausible strategies. Improving the economic efficiency of firms is, therefore, the first best step to be adopted.

The contribution of increased level of output can be enhanced if the efficiency of firms can be improved with the existing level of input utilization and available technology. Available evidence shows that little attention has been given to a systematic analysis of the efficiency of resource use in the Ethiopian food processing industry.

Therefore, this study can be considered as a step forward towards bridging this gap by using switching regression model with general objective of analyze the economic efficiency differences between private and public food processing firms in Ethiopia,.

The specific objectives of the study are:

- i. To measure the firm-level efficiency differential between private and public owned food processing firms
- ii. To identify important factors causing efficiency differentials between private firms and public firms in food processing industry.
- iii. To draw policy implications based on efficiency estimates of food processing industry in Ethiopia.

An appropriate research questions specific to efficiency differences between private and public food processing firms in Ethiopian food processing industry are:

- i. There is no systematic significant difference between public and private operators in terms of efficiency
- ii. What are the determinants of Economic efficiency in food processing industry in Ethiopia?

Developing economies can benefit much from efficiency studies that show the possibility of increasing productivity by improving efficiency without increasing the resource base or developing new technologies.

Measurements of the extent and determinants of efficiency indicate which aspects of firm characteristics can be addressed by public or private investment to improve efficiency.

Such study helps to know whether it is possible to raise productivity by improving firm efficiency or to develop new technologies to raise productivity. Thus by analyzing the efficiency differential between private and public firms, it is expected to generate pertinent information for different stakeholders and give appropriate policy recommendations designed to increase efficiency in the indicated industry.

Though the analysis of economic efficiency of a firm encompasses the subsequent effect of many years data this study is limited only to six years firm level data, as there is no enough data beyond these years .The study limited on secondary data prepared by Central Statistical Authority (CSA).The study is also limited to the analysis of economic efficiency of the solid food processing firms. Other liquid food processing firms are not included in the estimation of efficiency .Despite these limitations, the study is expected to generate valuable information.

The rest of the paper is organized as follows. Section two deals with the review of theoretical and empirical literature. Section three presents the methodology used in this study. Section four presents and discusses the results of the study. Finally section five summarizes, concludes the main empirical findings and draws appropriate recommendations.

II. Literature Review

2.1. Efficiency

Efficiency measurement has received considerable attention from both theoretical and applied economists. From a theoretical point of view, there has been a spirited exchange about the relative importance of the various components of firm efficiency (Leibenstein, 1966). From an applied perspective, measuring efficiency is important because this is the first step in a process that might lead to substantial resource savings. These resource savings have important implications for both policy formulation and firm management.

The current interest in efficiency measurement finds its origin in a pioneering paper published by M. J. Farrell over thirty years ago. The approach proposed by Farrell distinguishes between technical and allocative efficiency where the former refers to the ability of producing a given level of output with a minimum quantity of inputs, given technology. A firm is technically efficient if it produces the maximum obtainable level of output from a certain amount of inputs, given its technology. A firm is allocative efficient if production inputs are allocated according to their relative prices. Economic efficiency (EE) is the degree of ability of a firm to produce a given level of output at least cost. Economic or total efficiency is the product of technical and allocative efficiency (Farrell, 1957).

Given the technology, technical efficiency is the ability of a firm to produce on production frontier. Any feasible points below the frontier line are all technically inefficient; however, technical efficiency accounts for only physical inputs and outputs and does not account for

price of inputs and outputs, which deals with allocative efficiency. Allocative efficiency (AE) is the ability of a firm to produce a given level of output using cost minimizing input ratios.

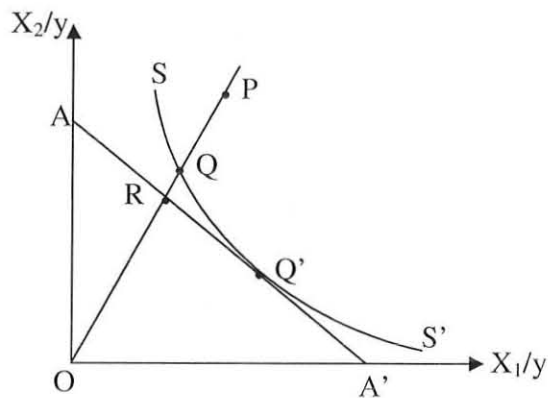


Figure 1 Technical and allocative efficiencies

Source; Coelli et al (1998), Fekadu,(2004)

Knowledge of a unit isoquant of fully efficient firms represented by SS' , in Figure 1, permits the measurement of efficiency. If a given firm uses quantities of inputs defined by the point P to produce a unit of output, the technical efficiency of that firm could be represented by the distance QP , which is the amount by which all resources could be proportionally reduced without a reduction in output. This is usually expressed in percentage term by the ratio of $\frac{QP}{OP}$, which represents the percentage by which all inputs need to be reduced to achieve technically efficient production.

The technical efficiency is most commonly measured by the ratio

$$TE = \frac{OQ}{OP} \dots\dots\dots (2.1) \text{ Which is equal to one minus } \frac{QP}{OP}$$

If the input price ratio, represented by the isocost line, AA', is also known, allocative efficiency (AE) of a firm operating at point P could be measured as the ratio

$$AE = \frac{OR}{OQ} \dots\dots\dots (2.2)$$

Since the distance RQ represents the reduction in production costs that would occur if production were to occur at the allocative (and technically) efficient point Q', instead of at the technically efficient but allocative inefficient, point Q. The product of the technical efficiency and allocative efficiency provides the measurement of overall economic efficiency, that is,

$$EE = TE * AE = \frac{OQ}{OP} * \frac{OR}{OQ} \dots\dots\dots (2.3)$$

Economic efficiency combines technical and allocative efficiency. It is possible for a firm to have either technical or allocative efficiency without having economic efficiency. Technical and allocative efficiency are necessary, and when they occur together, are sufficient conditions for achieving economic efficiency (Yotopoulos and Nugent, 1976).

2.2. Approaches of Efficiency Measurement

Many empirical studies of efficiency were devoted in analyzing what impact a given model specification has on the efficiency measurements. Various issues pertaining to model specification are still debating. The selection of specific frontier model depends upon many considerations such as the type of data, cross-sectional or panel data, the underlying behavioral assumptions of firms, the relevance to consider and extent of noise in the data and the objective of the study.

2.2.1. Non-parametric frontier models

One method of analyzing efficiency, which has been used in empirical studies, is non-parametric method. Any non-parametric model as opposed to parametric models doesn't require assumption as to the distributional behavior of the population. The principal and most commonly used model in the analysis of efficiency is data envelopment analysis (DEA). The DEA frontier is non-parametric, non-stochastic since it does not impose any a priori parametric restrictions on the underlying frontier technology (because doesn't necessitate any functional form to be specified for the frontier methodology) and doesn't require any distributional assumption for the technical inefficiency term. Therefore, the method avoids the imposition of unwarranted structures on both the frontier technology and the inefficiency component that might create distortion in the measurement of efficiency. The minimum assumptions required for this DEA frontier methodology are monotonicity and convexity of the efficient frontier (Banker et al., 1984).

In addition to this, it does not require any distributional form to the inefficiency effects; it is constructed from the observed input-output ratios using linear programming techniques.

Farrell's model, which is known as a deterministic nonparametric frontier (Forsund, Lovell and Schmidt) attributes any deviation from the frontier to inefficiency and imposes no functional form on the data. Several extensions of Farrell's deterministic model have been made by Aigner and Chu, Timmer, Afriat, Richmond, Schmidt (1976), and Greene, among others. A deficiency characterizing all deterministic frontier models is their sensitivity to extreme observations.

Coelli et al. (1998) summarized the following advantages of DEA; It can handle multiple inputs and multiple outputs, it doesn't require an assumption of a functional form relating input to outputs, it doesn't require a priori assumption with regard to the distribution of inefficiency parameter as in the case of parametric frontier models and it is unit invariant. However, there are also many drawbacks that are related to DEA. The main criticism of DEA is that it assumes all deviations from the frontier are due to inefficiency. Due to this, non-parametric frontier methodology may overstate inefficiencies and hence outliers may have profound effect on the magnitude of inefficiency (Llewelyn and Williams, 1996).

The other drawback of DEA is that it is not possible to test the hypotheses regarding the existence of inefficiency and the structure of the production technology that were possible in stochastic production frontier analysis. Moreover, Neff et al., (1993) noted that many of the observations in non-parametric frontier method are self-referencing and hence the method is unable to form a reference technology that includes other firms.

Generally most researchers, among others Coelli et al. (1998), Mohammad and Premachandra (2003), Ajibefun (2002), Parikh and Shan (1996) and others agree that stochastic frontiers are likely to be more appropriate than DEA .

2.2.2. Parametric Frontier Model

With regard to functional forms, Coelli et al. (1998) discussed three common functional forms namely Cobb-Douglas, translog and Zellner-Revankar generalized production functions. Each functional form has its own strength and shortcomings. The Cobb-Douglas functional form has been commonly used in the empirical estimation of frontier models. Its simplicity is a very attractive feature.



This simplicity however, is associated with a number of restrictive features like constant elastic ties, constant return to scale for all firms and elasticity of substitution are equal to one.

On the other hand, the translog functional form imposes no restrictions upon returns to scale or substitution possibilities and the Zellner-Revankar form removes the return to scale restriction. However, these functional forms are susceptible to multi co linearity and degree of freedom problem (Coelli et al., 1998). Battese and Broca (1996) pointed out that Cobb-Douglas and Translog are the two most common functional forms that have been used in empirical studies on production, including frontier analysis. Thiam et al. (2001) in their meta-analysis of empirical technical efficiency studies in developing countries found that the Cobb-Douglas functional form yield significantly lower average technical efficiency indices than those relying on the translog specification, which implies that more restricted functional forms lead to lower average estimates.

In parametric methods to frontier estimation, the frontier is represented through a functional form (e.g.a Cobb- Douglas or a Translog) derived with econometric techniques (Greene,1993).

Within the parametric methods, it is possible to distinguish between the deterministic (Aigner and Chu, 1968; Gabrielson, 1975) and stochastic (Aigner, Lovell and Schmidt, 1977) approaches to frontier estimation.

Deterministic techniques do not accommodate for stochastic shocks to production and cost, and therefore deviations from the frontier are entirely attributed to inefficiency. This strong assumption has induced econometricians to abandon deterministic frontiers as a useful model for efficiency measurement in favor of stochastic frontier models. In this case, each producer

faces a production frontier which is randomly placed by the whole collection of stochastic shocks outside his/her control

A more recent approach for measuring efficiency, which seeks to ameliorate the extreme observation problem, is the stochastic frontier model developed by Aigner, Lovell, and Schmidt, and by Meeusen and van den Broeck. The stochastic frontier model assumes an error term with two additive components –a symmetric component which accounts for pure random factors, and a one-sided component which captures the effects of inefficiency relative to the stochastic frontier. A recent extension by Jondrow et al. has solved the previous inability of deriving individual firm efficiency measures from stochastic frontiers. Farrell's model allows the computation of allocative, technical and, hence, of economic efficiency, but this computation is restricted to a technology exhibiting constant returns to scale.

Recent work by Kopp and Diewert, Akridge, Kumbhakar, and Schmidt and Lovell has led to alternative formulations of parametric models which relax the linear homogeneity restriction while enabling the calculation of the various efficiency indexes. The stochastic model formulation yields technical, allocative and economic efficiency measures that are free from distortions, stemming from statistical noise, inherent in deterministic models. In addition, the model makes possible a comprehensive efficiency analysis relying only on the econometric estimation of a production frontier, which is helpful because the firm-level price data required to estimate dual (cost or profit) models are often unavailable or inadequate (Quiggin and Bui-Lan).

III. Research Methodology

3.1. Description of data and definition of variables.

This study used secondary data on large and medium scale manufacturing and electricity industries collected by Central Statistical Authority (CSA) as a part of annual surveys of large and medium scale manufacturing and electricity industries. The data set has its own limitations. Enterprises either reported missing values, highly exaggerated figures or at times they could even become totally out of sight in the data set .As a result seventy three firms that have complete data in the study year were taken. The study used a panel data set for a period of six years (2002-2007).

In this study a combination of purposive and random sampling techniques were used to draw the sample, accordingly, a total of six firms out of seven from manufacture Production, processing and preserving of meat, fruit and vegetable, fourteen firms out of twenty eight from manufacture of edible oil, two firms out of three from manufacture of dairy products, twenty firms out of seventy four from manufacture of flour, nineteen out of one hundred firm from manufacture of baker, five firms out of eleven from manufacture of sugar and confectionary, three out of six firms from manufacture of pasta and macaroni and four out of twelve firms from manufacture of food NEC were selected .

Variables used in the model defined as follow:

Gross Value of Production: - includes the sales value of all products of the establishment, the net change of stocks between the beginning and end of the reference period in the value of finished goods and the value of semi finished goods, the value of industrial services rendered to others, the

value of goods bought and resold without any transformation or processing, and other receipts. The valuation of Gross Value of Production is in terms of producers' values where indirect taxes are included in the value of sales of the establishment and the value of subsidies received is excluded.

Raw Materials: - include all raw and auxiliary materials, parts and containers which are consumed during the reference year. The value of local raw materials is the value of locally produced raw materials and is the cost at the factory which includes the purchase price, transport charges, taxes and other incidental costs. The value of imported raw materials is the value of raw materials produced in other countries and obtained directly or from local source and is the cost at the factory which includes the purchase price, transport charges, taxes and other incidental costs.

Industrial Cost: - Includes the cost of raw materials, fuels, and other supplies consumed, cost of industrial services rendered by others, cost of goods bought and resold without any transformation or processing and cost of electricity consumed.

Fixed Capital Assets: - are those with a productive life of one year or more which are intended for the use of the establishment including fixed assets made by the establishment's own labor force for its own use. They are valued in this report at book-value at the end of the reference year that is the net book value at the beginning, plus new capital expenditure minus those sold and disposed and depreciation during the reference year.

Wages and Salaries: - includes all payments in cash or in kind made to employees during the reference year in connection with the work done for the establishments.

Paid -up Capital: - is that part of the issued capital of an establishment that has been paid by the shareholders or the individual owner.

3.2. Switching regression model

In broad terms, a switching regression model corrects for self-selection bias by introducing a set of self-selectivity variables into the production model (Daniel et al, 2007). In doing so, the first step in this model is to determine factors influencing firms' in production of output. Consistent with Freeman *et al*(1998) the type of ownership can be determined by a criterion function, which is postulated to be associated with exogenous firms economic variables as follows: $A_i = \delta'Z_i + u_{io}$ (3.1) where A is ownership type, i denotes firms, Z is a vector of exogenous variable, δ are the unknown parameters and u_{io} is the disturbance term.

Petersen (2001) indicates that to obtain robust results it is best to classify the dataset into a few broad groups, because defining several narrow groups may reduce significantly the variation within subgroups thus affecting the statistical significance of the econometric estimates. Therefore, whole sample divided into two ownership type – Private and public.

By dividing the sample in two subgroups, the dependent variable can be redefined as a dichotomous variable (i.e.1 for privately owned firm and 0 for public owned firms) and the parameters in Equation (3.1) can then be estimated as a Probit model. The second step in the switching regression model is to estimate production functions for the two groups of firms.

$$Y_{1i} = \beta_{1i}X_{1i} + u_{1i}, \text{ if A is private.....(3.2)}$$

$$Y_{2i} = \beta_{2i}X_{2i} + u_{2i}, \text{ if A is public.....(3.3)}$$

where Y_1 and Y_2 represent output for firms with private and public ownership type, respectively. X_1 and X_2 are vectors of exogenous variables, β_1 and β_2 are unknown parameters.

Maddala(1983) indicates that estimating the unknown parameters β_1 and β_2 , using OLS, yields inconsistent estimates because the expected values of the error terms, conditional on the sample selection criterion, are non-zero. In order to obtain unbiased estimates it is necessary to estimate equation (3.1) – (3.3) simultaneously using maximum likelihood techniques.

The estimation of this system of equations using maximum likelihood is feasible but complicated. To simplify the estimation, Lee(1978) suggested that two step method where self selectivity is treated as a missing variable problem .In this model the error terms are assumed to have a joint- normal distribution with the following covariance matrix:

$$\text{Cov} (u_1, u_2, u_0) = \begin{bmatrix} \sigma_1^2 & \sigma_{12}^2 & \sigma_{10}^2 \\ \sigma_{12}^2 & \sigma_2^2 & \sigma_{20}^2 \\ \sigma_{10}^2 & \sigma_{20}^2 & \sigma_0^2 \end{bmatrix}$$

where $\sigma_i^2 = \text{var}(u_i)$ and $\sigma_{ij}^2 = \text{cov}(u_i, u_j)$, $i \neq j$

Based on these assumptions, the expected values of the truncated error terms are equal to:

$$E = (u_1 | A_{=1} ,) = E(u_1 | u_o \geq Z' \delta) = \sigma_{10} \frac{\phi(Z_i' \delta)}{\Phi(Z_i' \delta)} = \sigma_{10} W_1 \dots\dots\dots(3.4)$$

$$E = (u_2 | A_{=0} ,) = E(u_2 | u_o \leq Z' \delta) = \sigma_{20} \frac{-\phi(Z_i' \delta)}{1 - \Phi(Z_i' \delta)} = \sigma_{20} W_2 \dots\dots\dots(3.5)$$

where Z and δ are, respectively, the vector of exogenous variables and the estimated parameters from Equation (3.1), ϕ and Φ are the probability density and the cumulative distribution functions.

Thus, consistent with Lee (1978), the revised system of equations can be depicted as:

$$Y_{1i} = \beta_{1i}X_{1i} + \sigma_{10}W_1 + \varepsilon_1, \text{ if A is private..... (3.6)}$$

$$Y_{2i} = \beta_{2i}X_{2i} + \sigma_{20}W_2 + \varepsilon_2, \text{ if A is public.....(3.7)}$$

where W_1 and W_2 are the self-selectivity variables derived, respectively, in Equations (3.4) and (3.5). The coefficients of these variables provide estimates of the covariance terms σ_{10} and, σ_{20} , if the co variances are non-zero then the estimation of Equations (3.2) and (3.3) would be biased due to self-selection.

According to Sriboonchitta and Wiboonpongse (2004) the methodology described above can also be used to modify the stochastic production frontier (SPF) model in order to estimate efficient parameters in the presence of self- selectivity bias.

The stochastic frontier production and cost models of Cobb-Douglas functional form is employed to estimate the firm – level technical, economic and allocative efficiencies of food processing industry in Ethiopia. As Ogundari (2006) indicated in his paper, the Cobb-Douglas Functional form is used because: the functional form has been widely used in firm efficiency for the developing and developed countries, the functional form meets the requirement of being self-dual, allowing an examination of economic efficiency and the functional form has a limited effects on empirical efficiency measurement (Kopp and Smith, 1980).

The Cobb-Douglas production functional form which specifies the production technology of the firms is expressed as follows:

$$Y_{1i} = \beta_{1i} X_{1i} + \sigma_{10} W_1 + v_{1i} - \mu_{1i}, \text{ if A is private} \dots \dots \dots (3.8)$$

$$Y_{2i} = \beta_{2i} X_{2i} + \sigma_{20} W_2 + v_{2i} - \mu_{2i}, \text{ if A is public} \dots \dots \dots (3.9)$$

Where Y_{it} represents the value of output, X_{it} represents the quantity of input used in the production. The V_i 's are assumed to be independent and identically distributed random errors, having normal $N(0, \sigma_v^2)$ distribution and independent of the U_i 's. The U_i s are technical inefficiency effects, which are assumed to be non-negative truncation of the half-normal distribution $N(\mu, \sigma_u^2)$. The technical efficiency of individual firm is defined in terms of the ratio of observed output to the corresponding frontiers output, conditional on the level of input used by the firms. Hence the technical efficiency of the firm is expressed as

$$TE_{it} = \frac{Y_{it}}{Y_{it}^*} = \frac{f(X_{it}; \beta) \exp(V_{it} - U_{it})}{f(X_{it}; \beta) \exp(V_{it})} = \exp(-U_{it}) \dots \dots \dots (3.10)$$

Where: Y_{it} is the observed output and Y_{it}^* is the frontiers output.

The TE ranges between 0 and 1.

The corresponding cost frontier of Cobb- Douglas functional form which is the basis of estimating firm level overall economic efficiency is specified as follows:

$$C_{1i} = \alpha_{1i} P_{1i} + \alpha_1 \ln Y_{1it}^* + \sigma_{10} W_1 + v_{1i} - \mu_{1i}, \text{ if A is private} \dots \dots \dots (3.11)$$

$$C_{2i} = \alpha_{2i} P_{2i} + \alpha_2 \ln Y_{2it}^* + \sigma_{20} W_2 + v_{2i} - \mu_{2i}, \text{ if A is public} \dots \dots \dots (3.12)$$

Where C_{it} represents the total input cost of the i^{th} farms in t^{th} year; Y_{it}^* represents adjusted output for noise; P_{it} represents input prices employed by the i^{th} firm in t^{th} year in food processing firms and measured in birr; α is the parameter to be estimated, V_{it} 's and U_{it} 's are random errors and assumed to be independent and identically distributed truncations (at zero) of the $N(\mu, \sigma_U^2)$ distribution. U_{it} provides information on the level of allocative efficiency of the i^{th} firm in t^{th} year.

The firm specific economic efficiency (EE) is defined in terms of the ratio of the predicted minimum cost (C_{it}^*) to observed cost (C_{it}). That is:

$$EE_{it} = \frac{C_{it}^*}{C_{it}} = \exp(U_{it}) \dots \dots \dots (3.13)$$

Hence, economic efficiency ranges between zero and one.

The stochastic frontier functions (production and cost) are estimated through maximum likelihood methods. For this study, the computer program FRONTIER version 4.1c was used.

However, it should be noted that this computer program estimates the cost efficiency (CE), which is computed originally as the inverse of equation (3.13). Hence, firm –level economic

efficiency (EE) was obtained using the relationship: $EE = \frac{1}{\text{cost efficiency}(CE)}$, that is EE is

the inverse of CE(Ogundari and Ojo,2006).

3.3. Method of Data Analysis

Descriptive statistics (mean and standard deviation) and stochastic frontier production and cost functions were used to analyze the economic characteristics, technical and allocative efficiency of the firms respectively. While the firm's economic efficiencies estimated as the product of TE and AE.

The production technology of the firms assumed to be specified by the Cobb-Douglas frontier production function which is defined by:

$$\ln Y_{it} = \beta_0 + \beta_1 \ln X_{1it} + \beta_2 \ln X_{2it} + \beta_3 \ln X_{3it} + \beta_4 \ln X_{4it} + \beta_5 \text{IMR}_{it} + V_{it} - U_{it} \dots \dots \dots (3.14)$$

Where Y_{it} = Gross Value of Production (GVP) of i^{th} firm at t^{th} time period measured in Birr, X_{1it} = Industrial cost measured in Birr, X_{2it} = labor in manday, X_{3it} = Fixed capital measured in Birr and X_{4it} is quantity of raw material measured in kilogram and IMR is Inverse Mills Ratio generated to treat selectivity bias.

The Cobb-Douglas cost frontier function for the food processing firms specified and defined as follows:

$$\ln C_{it} = \alpha_0 + \alpha_1 \ln Y_{it}^* + \alpha_2 \ln P_{1it} + \alpha_3 \ln P_{2it} + \alpha_4 \ln P_{3it} + \alpha_5 \text{IMR}_{it} + V_{it} + U_{it} \dots \dots \dots (3.15)$$

Where C_{it} = total cost of production of i^{th} firm at t^{th} time period measured in Birr; Y_{it}^* is adjusted output for noise; P_{1it} = cost of labor (wage in birr); P_{2it} = cost of capital (depreciation in birr); P_{3it} = cost of raw materials (in birr).

The technical and cost inefficiency effects μ_{it} is defined by:

$$\mu_{it} = \delta_0 + \delta_1 Z_{1it} + \delta_2 Z_{2it} + \delta_3 D_{it} + \delta_4 t \dots \dots \dots (3.16) \text{ where;}$$

Z_{1it} represents firm size of the i^{th} firm at t^{th} time period, which is number of permanent workers engaged.

Z_{2it} represents firm age of the i^{th} firm at t^{th} time period, which is number of years of operation of the firm.

D_{it} represents privatization dummy; where $D = 1$ if the firm transferred to private through privatization and $D = 0$ for public.

t represents time period

Size and age entered in the function because they affect TE of firm in most cases and time is entered in the function to allow for possible shifts in the frontier over time and the parameter involving the input variables are assumed to be time-invariant (Rebka, 2001).

3.4. Log likelihood ratio test

For this study, two different models were estimated. Model 1 is the traditional response function in which the inefficiency effects are not present. It is a special case of the stochastic frontier production function model in which the total variation of output from the frontier output due to technical inefficiency is zero, that is, $\gamma = 0$. Model 2 is the general model where there is no restriction and thus $\gamma > 0$. The two models were compared for the presence of technical inefficiency effects using the generalized log likelihood ratio test which is based on a comparison of two maximum –likelihood estimators, generated by maximizing the constrained and unconstrained likelihood functions.

The statistics is asymptotically equal to chi-square (χ^2).

$$\chi^2_{\text{cal}} = -2\{\ln [L (H_0) - L (H_a)]\} \dots\dots\dots (3.17)$$

H_0 is the null hypothesis that $\gamma = 0$, implying there is no significant inefficiency difference among firms and the operation of the industry would be better characterized by OLS. The alternative hypothesis: $H_a > 0$ is accepted in all three cases (Table 4) which suggests that TI is indeed stochastic.

It is given as the value of the likelihood function for the frontier model and H_a is the alternative hypothesis that $\gamma > 0$ for the general frontier model.

IV. Results and Discussion

4.1 Descriptive statistics

The descriptive statistics of the variables for the frontier estimation is presented in Table 1 and Table 2. It includes the sample mean, the standard deviation, and the minimum and maximum values for each of the variables in Cobb Douglas production and cost function. The mean value of Birr 36774409.9, 13731182 and 7842947510, as total value production at market price was obtained in ALL (private and public), private and public firms respectively. From the data analysis with a standard deviation of Birr 89247689.2, 40381231 and 129568461, the large size of the standard deviation conforms to the fact that most firms operate at differently.

Analysis of cost variables of the firms shows that mean cost of labor Birr 1816081, 301233.8 and 4554460 accounts for All (private and public), private and public firms respectively, which shows that cost of labor was highest in public firms. Among cost of inputs used the mean cost of raw material accounts for 23795649, 13873407 and 417320 in ALL (private and public), private and public firms respectively. Cost of raw material was the highest cost than cost of labor and cost of capital in the indicated three models.

Variable representing the economic characteristics of the firms employed in the analysis of the determinant of technical, allocative and economic efficiency includes; age of the firms, size, privatization and time. The average age of the firms was 30.62, 26.05 and 38.88 years in ALL (private and public), private and public firms respectively. The average number of total permanent employees (size) of the firms was 147.66, 63.63 and 299.55 in ALL (private and public), private and public firms respectively; meaning that on average public firms absorbs large number of employees than private firms.

Table1 Descriptive statistics result of Cobb Douglas production function

		All (Private and Public)							
	Output	Industrial Cost	Labor man day	Fixed Capital	Raw material	Age	Size	Privatize	Time
Mean	36774409.9	9128218	23744.9	9892249	8464513	30.6	147.7	0.10	3.5
SD	89247689.2	18703614	44132.8	45544902	76806752	19.3	348.1	0.3	1.7
Min	52000	8720.004	750	2348	38.2	6	10	0	1
Max	622776000	1.45E+08	303000	691276608	113+09	78	2542	1	6
		Private							
Mean	13731182	3517402	11555.9	4865220	2909259	26.1	63.6	0.1	3.5
SD	40381231	6123402	23308.76	12322869	21351495	18.2	166.4	0.4	1.7
Min	67200	33039.9	750	2348	38.2	6	10	0	1
Max	622776000	31892773	226500	112956331	316771782	78	2330	1	6
		Public							
Mean	78429475	19270847	45778.9	18979571	18506704	38.9	299.6	0	3.5
SD	129568461	27522579	61215.9	73782864	1.25E+08	18.4	505.3	0	1.71
Min	52000	8720	750	9201	553.7	10	10	0	1
Max	616046454	144770458	303000	691276608	113+09	78	2542	0	6

Output, industrial cost and fixed capital are in birr, raw material in kg, age and time in year ,privatize is dummy.
Source: own computation, (2009). Birr is an Ethiopian currency.

Table 2 Descriptive statistics result of Cobb Douglas cost function

	All (Private and Public)								
	Total Cost	Output	Cost of labor	Cost of capital	Cost of Raw Mat	Age	Size	Privatize	Time
Mean	9128218.1	36774410	1816081	3111571	23795649	30.6	147.7	0.2	3.5
SD	18703613.8	89247689	6549183	27081009	59755040	19.3	348.1	0.4	1.7
Min	8720.004213	52000	480	52	4968	6	10	0	1
Max	144770458.3	622776000	71581959	547168668	950315345	78	2542	1	6
Private									
Mean	3517402	13731182	301233.8	1170246	13873407	26.1	63.6	0.14	3.5
SD	6123402	40381231	570020.1	3324473	59860459	18.2	166.4	0.4	1.7
Min	33039.86	67200	480	52	11723	6	10	0	1
Max	31892773	622776000	3876421	27425739	950315345	78	2330	1	6
Public									
Mean	19270847	78429475	4554460	6620889	41732010	38.9	299.6	0	3.5
SD	27522579	129568461	10421903	45037468	55388948	18.4	505.3	0	1.7
Min	8720.004	52000	14880	531	4968	10	10	0	1
Max	144770458	616046454	71581959	547168668	313950464	78	2542	0	6

Output, industrial cost and fixed capital are in birr, raw material in kg, age and time in year ,privatize is dummy.
Source: own computation,(2009).Birr is an Ethiopian currency.

4.2. Econometric results

4.2.1. First-stage: Probit model

Table 3 presents the maximum-likelihood estimates of the Probit model. This table displays the estimated coefficients along with their respective marginal effects (MEs). The MEs measure the change in the probability of ownership due to a one unit change of a specific explanatory variable. The MEs for the dummy variables are estimated by taking the difference between the value of the prediction when the exogenous variable equals 1 and when it equals 0. By contrast, the MEs for the continuous variables are estimated as $ME = \varphi(\delta Z) \delta$, where φ is the probability density function, Z is the vector of exogenous variables and δ are the estimated parameters (Maddala, 1983). The MEs for both kinds of variables are measured at the mean value of the regressors. As shown in Table 3, the model correctly predicts ownership type to produce efficiently for 82 per cent of the observations and the likelihood ratio test rejects the null hypothesis that all slope coefficients are equal to zero at least at the 5 per cent level. The main result of the Probit model conformed privatization was positive and significant parameter.

Table 3 First stage Probit model.

Variable	Coefficient	SE.	Z	P> Z
Constant	0.61	0.088	7.68	0.000
Initial paid up capital	-0.000000001	0.000000004	-2.39	0.017
Privatization	0.83	0.24	3.39	0.001
Size	-0.002	0.0003	-5.40	0.000

4.2.2. Second-stage: efficiency analysis

In the second-stage estimates of the switching regression model used in this paper, three different stochastic production function (SPFs) were estimated to evaluate the effect of ownership on efficiency differences among private and public firms. The Private and Public models analyze efficiency differential among firms, which incorporate the self selectivity variables (W1) and (W2) generated in the first-stage analysis as Inverse Mills Ratio both for private and public firms respectively. If there is no selectivity bias then the parameters associated with W1 and W2 would not be statistically different from zero and direct estimation of the production model for each group (private and public) would be adequate (Freeman *et al.* 1998). For comparison, an SPF was also estimated for the entire sample (ALL).

The null hypothesis: $H_0: \gamma = 0$, implying there is no significant inefficiency difference among firms and the operation of the industry would be better characterized by OLS is rejected. The alternative hypothesis: $H_a: \gamma > 0$ is accepted in all three cases (Table 4) which suggests that TI is indeed stochastic.

Table 4 test of hypothesis for the inefficiency effect.

$H_0: \gamma = 0$, $H_a: \gamma > 0$						
Functions	Models	OLS	MLE	χ^2_{cal}	$\chi^2_{(6)5\%}$	Decision
Cobb Douglas Production Function	ALL	-892.04	-872.54	38.99	10.64	Rejection
	Private	-558.06	-541.15	33.81	10.64	Rejection
	Public	-344.72	-317.09	55.27	10.64	Rejection
Cobb Douglas Cost Function	ALL	-567.0	-554.76	24.48	10.64	Rejection
	Private	-361.58	-349.77	23.63	10.64	Rejection
	Public	-220.75	-209.73	22.05	10.64	Rejection

Source: Own computation (2009).

The values for σ^2 and γ are reported in Table 5 and Table 6, the value of γ for ALL, private and public SPF models are statistically significant and range from 0.8977, 0.8385 to 0.9687 respectively for Cobb Douglas production function and 0.53, 0.72 and 0.912 for Cobb Douglas cost function, which indicates that inefficiency is an important contributor to the observed output variability. The parameters for the self-selectivity variables W1 and W2 are statistically significant, which supports the estimation of the SPF using the switching regression approach. Furthermore, Fuglie and Bosch (1995) suggest that the signs of the parameters for W1 and W2 have important economic interpretations.

Assuming profit maximization, these authors conclude that if these parameters display the same sign, as is the case of Cobb Douglas production function, privately owned firms produce efficiently than their counterpart. The results show that out of the 38 estimated coefficients in the three SPF models 16, 10 and 2 are significant at least at the 1, 5 and 10 per cent level of significance. Both in private and public SPF models 7 and 2 parameters are significant at 1 and 5 percent level of significance respectively. In addition, 9 out of 38 of the estimated coefficients in the ALL SPF model 5, 4 are significant at 1 and 5 per cent level of significance.

In general, most the estimated production elastic ties follow similar patterns in the three estimated models; however, their magnitudes differ. Table 6 shows that, as industrial cost increases by one percent the value of production increase by 9, 8 and 16 percent in ALL, private and public SPF models. The contribution of labor and quantity of raw material are positive and at least significant at 5 percent level in ALL and Private SPF models but these variables contributes negatively in the public SPF model.

In the case of Cobb Douglas cost function only output and cost of raw material follow similar pattern which are positive and significance at 1 percent level of significance, the rest are mixed both in their sign and significance. Table 4 shows 23 out of 38 estimated coefficients are significant at least at 5 percent level of significance in the three SPFs models. The elasticities coefficient of output and cost of raw material indicates a one percent increase of the value of output and the cost of raw material, the total cost of the firm increased by 0.14,0.14 and 0.15,0.26,0.55 and 0.29 percents respectively in ALL, private and public SPFs models .

The effect of labor and cost of capital on total cost displays mixed parameters in all estimated models. Moreover, the statistical significance of these parameters varies, for instance, the parameters for cost of labor is positive in ALL and public SPFs models. It is important to indicate that the effect of labor on output presents mixed results in the literature. For example, Kompas and Che (2006), report positive and significant effects of labor on output among dairy producers in Australia. By contrast, no significant effects are reported by Wadud and White (2000) in Bangladesh and Squires and Tabor (1991) in Indonesia.

Table 5 Cobb Douglas Stochastic Production Function

		All	Private	Public
Variable	Parameter	Coef	Coef	Coef
<i>General Model</i>				
Value of product at market price				
Constant	β_0	9.23 *(12.22)	8.18 *(8.93)	16.36 *(10.21)
Industrial Cost	β_1	0.47 *(6.99)	0.54 *(6.23)	0.68 *(5.36)
Labor (man day)	β_2	0.24 *(2.61)	0.15 (1.36)	-0.18 (-0.92)
Fixed Capital (birr)	β_3	0.03 (0.75)	0.07 (1.39)	-0.04 (-0.72)
Quantity of raw Material	β_4	0.07 (1.60)	0.01 (0.26)	-0.15 *(16.57)
Inverse Mills Ratio	β_5	- -	2.14 *(3.97)	1.69 *(5.01)

Inefficiency Model

Constant	δ_0	-25.12 **(-2.40)	-28.21 **(-2.06)	-13.43 ***(-1.71)
Age	δ_1	-3.27 (-1.48)	-0.39 (-0.77)	-2.01 ***(-1.88)
Size	δ_2	4.19 **(2.16)	4.1 *(8.88)	2.38 **(2.49)
Privatization	δ_3	-6.97 **(-1.63)	-1.14 *(-2.72)	-28.06 (-0.94)
Time	δ_4	1.47 *(3.25)	0.85 **(2.4)	1.70 *(2.96)
<i>Variance parameters</i>				
Sigma-square	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	20.89 **(2.18)	12.83 *(2.86)	16.13 *(3.23)
Gamma	$\gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2}$	0.8977 *(17.98)	0.8385 *(15.53)	0.9687 *(67.09)
Log likelihood function	llf	-872.54	-541.15	-317.09

Figures in parenthesis are t-ratio

*, ** and *** Estimates are significant at 1%, 5% and 10% level of significance respectively.

Table 6 Cobb Douglas Stochastic Cost Function.

		All	Private	Public
Variable	Parameter	Coef	Coef	Coef
<i>General Model</i>				
Total Cost				
Constant	α_0	0.43 (0.59)	0.87 (0.81)	-0.3 *(-2.89)
Value of product at market price(birr)	α_1	0.14 *(4.97)	0.14 *(3.6)	0.15 *(3.28)
Cost of labor (birr)	α_2	0.66 *(14.18)	-0.04 (-1.37)	0.8 *(13.59)
Cost of capital (birr)	α_3	-0.05 **(-2.21)	0.30 *(6.48)	-0.05 (-1.05)
Cost of raw material (birr)	α_4	0.26 *(10.0)	0.55 *(5.88)	0.29 *(7.72)
Inverse Mills Ratio	α_5	- -	0.43 *** (1.81)	-0.89 *(-3.52)

Inefficiency Model

Constant	δ_0	2.44 *(2.57)	1.37 (0.59)	4.23 *(2.60)
Age	δ_1	-0.83 (-1.16)	-0.87 (-0.57)	-4.61 **(-2.31)
Size	δ_2	-0.18 (-0.77)	-0.21 (-0.74)	1.55 **(2.19)
Privatization	δ_3	-0.0044 (-0.013)	-1.12 (-0.76)	0.66 (0.65)
Time	δ_4	0.18 (0.84)	0.32 (0.47)	-1.40 **(-2.0)
Variance parameters				
Sigma-square	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	1.16 *** (1.82)	1.59 (0.74)	6.05 ** (2.25)
Gamma	$\gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2}$	0.53 ** (1.99)	0.72 ** (1.91)	0.912 * (19.35)
Log likelihood function	llf	-554.76	-349.77	-209.73

Figures in parenthesis are t-ratio

*, ** and *** Estimates are significant at 1%, 5% and 10% level of significance respectively

4.2.3. Technical efficiency, economic efficiency and allocative efficiency analysis

The technical efficiency analysis of food processing firms revealed that technical inefficiency effects existed in ALL, Private and Public models as confirmed respectively by the gamma value of 0.8977, 0.8385 and 0.9687 which was significant at 1 percent level (Table 5).

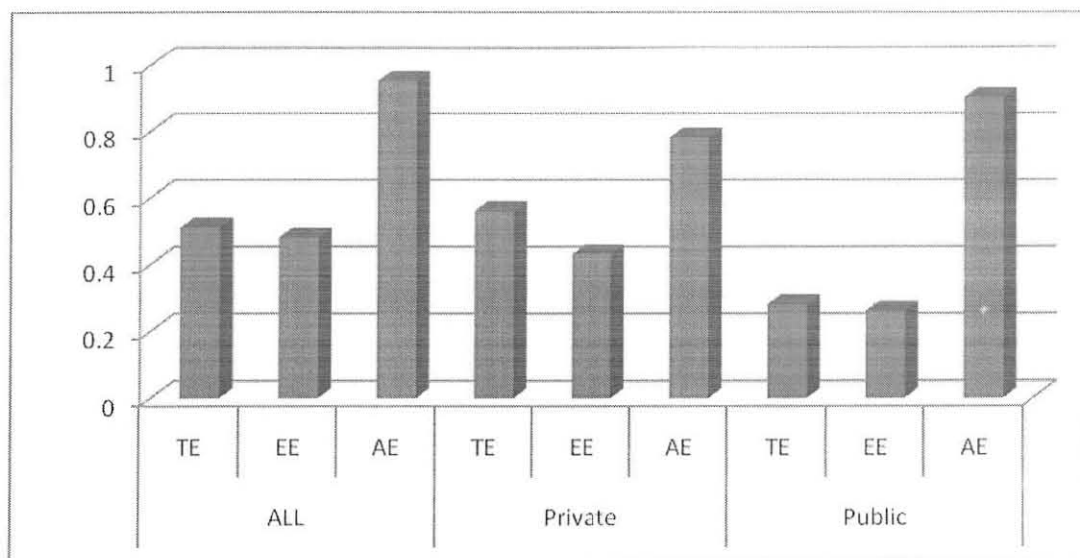
Hence, 0.8977, 0.8385 and 0.9687 implies that about 90, 84 and 97 percent variation in the output of ALL, private and public food processing firms was due to differences in their technical efficiencies.

Table 5 also presents the inefficiency effects for the three models. Following common practice, the analysis is performed in terms of TE instead of TI which is equivalent to assuming that the inefficiency effects parameters display the opposite sign as the one shown in Table 5. The parameters estimates for determinants of technical efficiency and cost efficiency were reported in the lower part of Table 5 and Table 6. The analysis of inefficiency models shows that the signs and significance of the estimated coefficient in the inefficiency model have important implication on the technical efficiency and cost efficiency of the firms under the study. Based on this, variables in the inefficiency model age and privatization have negative coefficients in the public and private model respectively, meaning that as the firm gets older both technical and cost efficiencies increases, the negative coefficients of age was not consistent with Rebka(2001) and which means that as the firms age increase the TE also increases, this is may be due to the fact that the efficiency gain through experience . The negative coefficient of privatization conform that transferring public firms to private improves TE as it allow competition in the sector, this is consistent with Rebka(2001).

The variable size (the total number of permanent employees) has positive coefficient in the inefficiency model as in the lower part of Table 5 and Table 6, meaning that as the size of firms increase the TE and CE decreases. The variable time has mixed coefficient in TI model and CI model, the positive coefficients of time in the former prevail that TE decreases through the time under the study.

The empirical results presented in the form of graph(Figure 2) show that the average levels of TE are 0.51, 0.56 and 0.28 for ALL, Private and Public models respectively. Based on paired *t*-tests, the differences among these means are statistically different from zero suggesting that, on average, firms which owned privately exhibit higher TE than firms owned publicly.

Figure 2 Mean efficiency of ALL, Private and Public models



Source: Own computation (2009).

The economic efficiency analysis of food processing firms revealed that there was presence of cost inefficiency effects as confirmed by the significance gamma value of 0.53, 0.72 and 0.912 at least at 5 percent level of significance (Table 5). This implies that about 53, 72 and 91 percent variation in the total production cost is due to differences in their cost efficiencies. The predicted economic efficiencies (EE) estimated as inverse of cost of efficiencies differs substantially among the firms, with a mean EE of 0.48, 0.43 and 0.26 in ALL, private and public models respectively as presented in Figure 2.

The predicted allocative efficiencies differ substantially among the firms with the mean AE of 0.95, 0.78 and 0.9 for ALL, private and public models respectively.



V. Summary, Conclusion and Recommendation

This study has assessed the connection between the ownership of firms and firms' TE, EE and AE by comparing two groups of firm, private and public food processing firms in Ethiopia.

A switching regression approach was used to test for a systematic difference between the two groups, this approach corrects for the potential self-selectivity problem using a two-stage procedure. First, a Probit model is estimated to evaluate the variables affecting the ownership among the sampled firms and to derive self-selectivity variables (IMRs). These self-selectivity variables are then introduced into two SPFs to compute unbiased estimators.

The results can be summarized as follows. First, the Probit model indicated that initial paid up capital and size of firm play a negative and significant role in determining ownership. By contrast, privatization plays a positive and significant effect on ownership, indicating that firms to be owned privately have a higher probability than to be owned publicly. In the second step a stochastic efficiency decomposition frontier analysis estimated to analyze the technical, economic and allocative efficiencies of food processing firm in Ethiopia. The analysis of private firms reveals an average level of technical, allocative and economic efficiency equal to 56 percent, 43 percent and 78 percent respectively and the analysis of public firms reveals an average level of technical, allocative and economic efficiency equal to 28 percent, 26 percent and 90 percent respectively.

Comparing the relative size of TE, AE and EE obtained from the analysis, which is a clear indication that on average private firms in the sample are technically, and economically efficient than public firms.

An important conclusion stemming from the analysis is that overall economic efficiency (EE) of food processing firms could be improved substantially and that technical inefficiency constitutes a more serious problem than allocative inefficiency. Hence, it is of this view worth pointing out that despite the role higher efficiency levels can have on output, productivity gains stemming from privatization remain of critical importance in the Ethiopian food processing sector. Therefore, efforts should be directed to speed up the ongoing process of privatization of public food processing firms.

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Appendices

Appendix1.

prob owner int_paid_up_capital privatiz size

Iteration 0: log likelihood = -285.21655
Iteration 1: log likelihood = -254.30503
Iteration 2: log likelihood = -249.89817
Iteration 3: log likelihood = -249.00534
Iteration 4: log likelihood = -248.98262
Iteration 5: log likelihood = -248.98261

Probit regression

Number of obs = 438

LR chi2(3) = 72.47

Prob > chi2 = 0.0000

Pseudo R2 = 0.1270

Log likelihood = -248.98261

owner	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
int_pd_up_	-1.10e-08	4.61e-09	-2.39	0.017	-2.00e-08	-1.98e-09
capital						
privatiz	.8274577	.244439	3.39	0.001	.3483659	1.306549
size	-.0017228	.0003188	-5.40	0.000	-.0023477	-.0010979
_cons	.6056883	.0788905	7.68	0.000	.4510658	.7603109

Note: 1 failure and 0 successes completely determined.

```
. predict p1, xb
. gen phi=(1/sqrt(2*_pi))*exp(-(p1^2/2))
. gen capphi=norm(p1)
. gen invmills=phi/capphi
. gen phii=-(1/sqrt(2*_pi))*exp(-(p1^2/2))
. gen caphii=1-norm(p1)
. gen invmillsB=phii/caphii
. replace invmills= 0 if ( owner==0)
(156 real changes made)
. replace invmillsB= 0 if ( owner==1)
(282 real changes made)
```

Appendix2.

Output from the program FRONTIER (Version 4.1c)

instruction file = terminal

data file = ALL1.dta.txt

Tech. Eff. Effects Frontier (see B&C 1993)

The model is a production function

The dependent variable is logged

the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.11816283E+02	0.73772359E+00	0.16017222E+02
beta 1	0.31211996E+00	0.70613990E-01	0.44200868E+01
beta 2	0.11248075E+00	0.96947512E-01	0.11602232E+01
beta 3	0.55581955E-02	0.40254435E-01	0.13807660E+00
beta 4	0.73864323E-01	0.45240015E-01	0.16327210E+01

sigma-squared 0.34792897E +01

log likelihood function = -0.89203605E+03

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.92313999E+01	0.75546830E+00	0.12219441E+02
beta 1	0.47388540E+00	0.67752121E-01	0.69943995E+01
beta 2	0.23555525E+00	0.90294146E-01	0.26087544E+01
beta 3	0.24778415E-01	0.32967236E-01	0.75160729E+00
beta 4	0.69210322E-01	0.43525059E-01	0.15901258E+01
delta 0	-0.25120017E+02	0.10452602E+02	-0.24032309E+01
delta 1	-0.32708863E+01	0.22106053E+01	-0.14796338E+01
delta 2	0.41865704E+01	0.19384703E+01	0.21597290E+01
delta 3	-0.69673202E+01	0.43005466E+01	-0.16201011E+01
delta 4	0.14673312E+01	0.45206510E+00	0.32458404E+01
sigma-squared	0.20888037E+02	0.95817910E+01	0.21799721E+01
gamma	0.89768019E+00	0.49924279E-01	0.17980834E+02

log likelihood function = -0.87253679E+03

LR test of the one-sided error = 0.38998533E+02

with number of restrictions = 6

[note that this statistic has a mixed chi-square distribution]

number of iterations = 30

(maximum number of iterations set at : 100)

number of cross-sections = 73

number of time periods = 6

total number of observations = 438

Appendix3.

Output from the program FRONTIER (Version 4.1c)

instruction file = terminal

data file = prv1.dta.txt

Tech. Eff. Effects Frontier (see B&C 1993)

The model is a production function

The dependent variable is logged

the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.10937647E+02	0.87322237E+00	0.12525615E+02
beta 1	0.42488324E+00	0.83716947E-01	0.50752357E+01
beta 2	0.11141421E+00	0.11390821E+00	0.97810512E+00
beta 3	0.20175335E-01	0.48649573E-01	0.41470734E+00
beta 4	0.13365006E-01	0.52454234E-01	0.25479365E+00
beta 5	-0.16407081E+00	0.45333792E+00	-0.36191723E+00

sigma-squared 0.31314326E+01

log likelihood function = -0.55805846E+03

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.81849827E+01	0.91622013E+00	0.89334237E+01
beta 1	0.53691050E+00	0.86227275E-01	0.62266899E+01
beta 2	0.14853500E+00	0.10895091E+00	0.13633205E+01
beta 3	0.68046885E-01	0.48831399E-01	0.13935067E+01

beta 4	0.13934890E-01	0.53822897E-01	0.25890264E+00
beta 5	0.21361116E+01	0.53768532E+00	0.39727914E+01
delta 0	-0.28214847E+02	0.13685440E+02	-0.20616690E+01
delta 1	-0.39044550E+00	0.50795537E+00	-0.76866102E+00
delta 2	0.41021244E+01	0.16442293E+01	0.24948615E+01
delta 3	-0.11437036E+02	0.41975431E+01	-0.27246978E+01
delta 4	0.85403720E+00	0.35627537E+00	0.23971267E+01
sigma-squared	0.12828312E+02	0.44924993E+01	0.28554957E+01
gamma	0.83854092E+00	0.53995508E-01	0.15529827E+02

log likelihood function = -0.54115290E+03

LR test of the one-sided error = 0.33811111E+02

with number of restrictions = 6

[note that this statistic has a mixed chi-square distribution]

number of iterations = 24

(maximum number of iterations set at : 100)

number of cross-sections = 47

number of time periods = 6

total number of observations = 282

Appendix4.

Output from the program FRONTIER (Version 4.1c)

instruction file = terminal

data file = publ.dta.txt

Tech. Eff. Effects Frontier (see B&C 1993)

The model is a production function

The dependent variable is logged

the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.16565499E+02	0.25126732E+01	0.65927790E+01
beta 1	0.11048202E+00	0.14898092E+00	0.74158504E+00
beta 2	0.70211474E-01	0.18495211E+00	0.37961975E+00
beta 3	-0.11139082E+00	0.78701791E-01	-0.14153531E+01
beta 4	0.12388893E+00	0.10949991E+00	0.11314067E+01
beta 5	0.35712474E+00	0.57166271E+00	0.62471234E+00

sigma-squared 0.50574072E+01

log likelihood function = -0.34472180E+03

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.16357071E+02	0.16013129E+01	0.10214787E+02
beta 1	0.68313240E+00	0.12741529E+00	0.53614634E+01
beta 2	-0.11774905E+00	0.12819399E+00	-0.91852238E+00
beta 3	-0.38183078E-01	0.53123392E-01	-0.71876205E+00

beta 4	-0.15448054E+00	0.93201397E-01	-0.16574916E+01
beta 5	0.16912983E+01	0.33727221E+00	0.50146388E+01
delta 0	-0.13427626E+02	0.78460329E+01	-0.17113905E+01
delta 1	-0.20077922E+01	0.10692974E+01	-0.18776743E+01
delta 2	0.23763912E+01	0.82474582E+00	0.28813620E+01
delta 3	-0.28058508E+02	0.29964875E+02	-0.93637996E+00
delta 4	0.17037604E+01	0.57471377E+00	0.29645372E+01
sigma-squared	0.16132886E+02	0.50002630E+01	0.32264074E+01
gamma	0.96874448E+00	0.14440343E-01	0.67085975E+02

log likelihood function = -0.31708719E+03

LR test of the one-sided error = 0.55269225E+02

with number of restrictions = 6

[note that this statistic has a mixed chi-square distribution]

number of iterations = 30

(maximum number of iterations set at : 100)

number of cross-sections = 26

number of time periods = 6

total number of observations = 156

Appendix5.

Output from the program FRONTIER (Version 4.1c)

instruction file = terminal

data file = ALL2.dta.txt

Tech. Eff. Effects Frontier (see B&C 1993)

The model is a cost function

The dependent variable is logged

the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.18187976E+01	0.39356920E+00	0.46212906E+01
beta 1	0.13658025E+00	0.27741756E-01	0.49232733E+01
beta 2	0.59512055E+00	0.26746081E-01	0.22250757E+02
beta 3	-0.53398668E-01	0.22838678E-01	-0.23380805E+01
beta 4	0.26717992E+00	0.25890585E-01	0.10319578E+02

sigma-squared 0.78871523E+00

log likelihood function = -0.56700105E+03

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.42660491E+00	0.72355591E+00	0.58959494E+00
beta 1	0.13977076E+00	0.28106325E-01	0.49729290E+01
beta 2	0.65756771E+00	0.46374406E-01	0.14179539E+02
beta 3	-0.51114218E-01	0.23139756E-01	-0.22089351E+01
beta 4	0.26468961E+00	0.26466848E-01	0.10000798E+02

delta 0	0.24440013E+01	0.94926920E+00	0.25746135E+01
delta 1	-0.83435546E+00	0.72131502E+00	-0.11567144E+01
delta 2	-0.18095329E+00	0.23402084E+00	-0.77323579E+00
delta 3	-0.44308052E-02	0.34205129E+00	-0.12953628E-01
delta 4	0.18003780E+00	0.21377345E+00	0.84218972E+00
sigma-squared	0.11637647E+01	0.63822261E+00	0.18234464E+01
gamma	0.53181294E+00	0.26760730E+00	0.19872886E+01

log likelihood function = -0.55476123E+03

LR test of the one-sided error = 0.24479640E+02

with number of restrictions = 6

[note that this statistic has a mixed chi-square distribution]

number of iterations = 22

(maximum number of iterations set at : 100)

number of cross-sections = 73

number of time periods = 6

total number of observations = 438

Appendix6.

Output from the program FRONTIER (Version 4.1c)

instruction file = terminal

data file = Prv2.dta.txt

Tech. Eff. Effects Frontier (see B&C 1993)

The model is a cost function

The dependent variable is logged

the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.18167885E+01	0.54289035E+00	0.33465109E+01
beta 1	0.16284598E+00	0.37811388E-01	0.43067971E+01
beta 2	-0.52622860E-01	0.27633213E-01	-0.19043338E+01
beta 3	0.29807079E+00	0.36962085E-01	0.80642310E+01
beta 4	0.50374108E+00	0.41536716E-01	0.12127610E+02
beta 5	0.44689654E+00	0.22842811E+00	0.19563991E+01

sigma-squared 0.77728729E+00

log likelihood function = -0.36158400E+03

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.86996200E+00	0.10774730E+01	0.80740958E+00
beta 1	0.14483454E+00	0.40136725E-01	0.36085291E+01
beta 2	-0.38415034E-01	0.28035541E-01	-0.13702262E+01
beta 3	0.28854067E+00	0.44652076E-01	0.64619766E+01

beta 4	0.55267170E+00	0.93972294E-01	0.58812196E+01
beta 5	0.42687885E+00	0.23555401E+00	0.18122334E+01
delta 0	0.13660552E+01	0.22932131E+01	0.59569484E+00
delta 1	-0.87255465E+00	0.15240296E+01	-0.57253129E+00
delta 2	-0.20998545E+00	0.28412593E+00	-0.73905768E+00
delta 3	-0.11974225E+01	0.15800314E+01	-0.75784726E+00
delta 4	0.32148180E+00	0.69116518E+00	0.46513020E+00
sigma-squared	0.15889058E+01	0.21567089E+01	0.73672703E+00
gamma	0.71567621E+00	0.37425167E+00	0.19122860E+01

log likelihood function = -0.34977130E+03

LR test of the one-sided error = 0.23625405E+02

with number of restrictions = 6

[note that this statistic has a mixed chi-square distribution]

number of iterations = 32

(maximum number of iterations set at : 100)

number of cross-sections = 47

number of time periods = 6

total number of observations = 282

Appendix7.

Output from the program FRONTIER (Version 4.1c)

instruction file = terminal

data file = Pub2.dta.txt

Tech. Eff. Effects Frontier (see B&C 1993)

The model is a cost function

The dependent variable is logged

the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.70767934E+00	0.13659476E+01	0.51808673E+00
beta 1	0.13404746E+00	0.50554332E-01	0.26515524E+01
beta 2	0.61203572E+00	0.60863736E-01	0.10055835E+02
beta 3	-0.83379754E-02	0.48730188E-01	-0.17110493E+00
beta 4	0.28594589E+00	0.40522383E-01	0.70564924E+01
beta 5	-0.14076695E+00	0.27952118E+00	-0.50360031E+00

Sigma-squared 0.10319894E+01

log likelihood function = -0.22075129E+03

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	-0.30039319E+01	0.10410117E+01	-0.28855891E+01
beta 1	0.15243492E+00	0.46513310E-01	0.32772323E+01
beta 2	0.80041260E+00	0.58865513E-01	0.13597309E+02
beta 3	-0.49029175E-01	0.46912020E-01	-0.10451303E+01

beta 4	0.28872244E+00	0.37421176E-01	0.77154828E+01
beta 5	-0.88839334E+00	0.25272164E+00	-0.35153038E+01
delta 0	0.42258490E+01	0.16225749E+01	0.26044092E+01
delta 1	-0.46067124E+01	0.19980330E+01	-0.23056237E+01
delta 2	0.15510954E+01	0.70816128E+00	0.21903137E+01
delta 3	0.65998061E+00	0.10074635E+01	0.65509136E+00
delta 4	-0.14014986E+01	0.69988427E+00	-0.20024719E+01
sigma-squared	0.60545948E+01	0.26951142E+01	0.22465077E+01
gamma	0.91189507E+00	0.47119949E-01	0.19352633E+02

log likelihood function = -0.20972507E+03

LR test of the one-sided error = 0.22052438E+02

with number of restrictions = 6

[note that this statistic has a mixed chi-square distribution]

number of iterations = 31

(maximum number of iterations set at : 100)

number of cross-sections = 26

number of time periods = 6

total number of observations = 156

DECLARATION

I, the undersigned, declare that this project work, except where duly acknowledged, is the product of my own original work and has not been presented in any University



Hailegebriel Yirdaw

Date: June 25, 2009

Place: Addis Ababa

Ethiopia