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Firm Level Technical Efficiency between Foreign-Owned and Domestic-Owned Firms: Case Study of Pharmaceutical Manufacturing Industry in Ghana

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Abstract

This study aims at comparing the levels of technical efficiency of domestic-owned and foreign-owned pharmaceutical manufacturing firms in Ghana and analyse the responsiveness of their respective outputs to capital and labour as major inputs. A stochastic frontier analysis based on the Cobb-Douglas production functional form was applied to estimate the parameters of the data and the technical efficiency of production among firms. The findings show that technical efficiency levels among foreign-owned firms range between about 47% and 88.6% with the mean technical efficiency level of 65.7% whilst those of the domestic-owned firms range between 40.33% and 75.05% with the mean efficiency level of 56.64%. The student t-ratio was used to test the equality of the mean values of efficiency. In addition, capital and skilled labour had greater positive impacts on output levels of capsules and tablets produced by the firms. It is recommended that domestic-owned firms enter into joint venture agreement with their counterpart foreign ones to promote technology transfer to their operations. This will ultimately enhance technical efficiency among domestic-owned firms and hence, make them operate closer to their potential frontiers (more technically efficient) so as to be more cost effective and competitive.

Keywords: capital; competition; domestic-owned firms; foreign-owned firms; frontier; Ghana labour; pharmaceutical manufacturing firms; technical efficiency.

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1. Introduction

It has been identified by experts that technical efficiency at firm-level is one of the major preconditions to industrial and economic development particularly in developing countries. In this direction, there is gradual divergence of policies in the developing countries towards the market-oriented models of 'Washington Consensus' development policies that have promoted privatization, competition in the spirit of trade liberalization and foreign direct investment. Thus, only firms that are near their technical efficiency frontiers can benefit from these policies and catch up with others as far as competition is concerned [1].

Thus, technical efficiency at firm-level tends to influence the operations of firms themselves and the country in which they operate. In respect of this, modern firms in developing countries apply their resources to ensure that they are technically efficient in order to survive competition that has characterised these countries as a result of waves of globalisation in the modern world. This compels firms in developing countries to adopt improved production technologies that will enable them optimize the use of their capital outlay and get closer to their potential maximum output levels. This, it is believed, will afford them the opportunity to reduce production cost and prices of their final products [2]. According to [2], the fact that firms become technically efficient enables them to add more value to primary products in developing countries and this has the tendency to increase export revenue earning capacities of these countries for further developmental activities. Furthermore, the desire of firms to be technically efficient encourages them to invest in research and development (R & D) activities and these impacts positively on most sectors of the economies in which they operate and thus, promote growth and national development [1].

Recent records of the state of industrial performance in Ghana give credence to the fact that enhancement of firm-level technical efficiency among Ghanaian firms cannot be over-emphasised. Ghana's implementation of the structural adjustment programme (SAP) in the 1980s and 1990s led to the privatization of over 300 state-owned enterprises by the end of the year 2000 having identified the private sector as the 'engine of growth'. This action of government was based on the widespread belief that private firms tend outperform state-owned enterprises and that privatization promotes operating efficiency of divested firms. Thus, Ghana government sold these firms mostly to foreign entrepreneurs including the multinational companies mostly from the western countries and these business entities became partially or wholly foreign-owned firms. This stresses again government subscription to the fact that foreign-owned private firms are more efficient than their counterpart domestic-owned ones.

In furtherance of the policy of promoting foreign direct investment in the country at the time, some specific policy measures have since been put in place by Ghana government. These include preferential policy treatment like tax holidays for foreign-owned firms for between the first 5 and 10 years of their establishment and operations. Domestic entrepreneurs have been complaining against such discriminatory treatment by the government against them. This move by the government has since, created public perception that foreign-owned firms are more technically efficient than domestic-owned firms in the country. It is also argued that outputs of foreign-owned firms are more responsive to capital than it is the case with domestic-owned firms.

This study therefore, is intended to scientifically ascertain the veracity of this perception by using the pharmaceutical manufacturing industrial sub-sector of the country as a case study. The choice of this sub-sector is informed by the fact that during the privatization exercise, the largest pharmaceutical entity in the country; Ghana Industrial Holdings Corporation (GIHOC) Pharmaceuticals, was wholly sold out to expatriate businessmen. Thus, the study addresses the following pertinent issues: Is the perceived problem of technical inefficiency linked to firm domestic or foreign ownership in the pharmaceutical industry? Are output levels of foreign-owned firms more responsive to capital than to labour? Based on this premise, this study seeks to find out whether or not foreign-owned firms are more technically efficient than their domestic-owned counterparts and to establish whether or not output levels of foreign-owned firms are more responsive to capital than to labour compared to the domestic-owned ones.

2. Theoretical framework

The classical work of [2] was initially developed based on the deterministic frontier approach which attributed the entire deviation of the actual output of firms from their potential maximum output to inefficiency of the firms. But the works of [3,4] were first to separately but concurrently identify that the deviation of firms' output from their potential maximum output was not entirely attributable to inefficiency. They established that it was partially attributable to both inefficiency of the firms and statistical noise or randomness associated with econometric model [5].

This became known as the traditional stochastic frontier model. Thus, the non-negative random aspect of the error term (i.e. one with half normal distribution) to produce a measurement of technical efficiency (inefficiency) or the ratio of actual output to the maximum output with the given inputs and the level of output is used. When firms in an industry operate at different levels of efficiency (inefficiency) as a result of poor technology, inadequate incentives, inappropriate input levels, mismanagement or less than perfectly competitive behaviour, the level of output could vary. Basically, the traditional stochastic frontier model is stated in Equation (1).

$$Y_i = f(x_i; \beta) + e_i; \; i = 1,2, \ldots, N; \quad N = \text{last firm.} \tag{1}$$

$e_i = v_i - u_i;$

Where Y_i represents the output level of the *i*th sample firm, $f(x_i; \beta)$ is a suitable function such as Cobb-Douglas or Translog production function of vector x_i of inputs for the ith firm and a vector β of unknown parameters. e_i is an error term made up of two components, vi and ui. v_i indicates a random error with zero mean and a constant variance N $(0;\sigma_v^2)$. On the other hand, u_i is a non-negative truncated half normal, independently and identically distributed random variable associated with firm-specific factors, N $(0, \sigma_u^2)$ which leads to the *i*th firm not attaining maximum efficiency of production [5].

2.1 Empirical Framework

The stochastic frontier production function developed by [3,4] as used by [6] is adopted to find technical efficiency level for firms. We assume that the frontier production function is of Cobb-Douglas or translog form as given in Equations (5) and (6). Two main reasons account for the adoption of this approach instead of the data envelopment analysis (DEA). First, it has the ability to consider both factors beyond the control of the firm and the technical inefficiency hence, it is closer to reality. Second, it separates the random variation of the frontier across firms as well as the effects of measurement error and other random shocks from the effect of inefficiency. With the use of a frontier production functional form, the methodology of the stochastic frontier approach is developed as in Equation (2).

$$Y = f(x\ ;\beta). \tag{2}$$

Equation (2) defines the technological link between inputs (x) and the resulting output (y) under the assumption that production is considered in an efficient manner and β represents unknown parameters to be estimated. Due to some degree of inefficiency, a firm potentially produces less than it might and as a result, its production function is stated in Equation (3).

$$y = f(x_i;\beta) * TE_i. \tag{3}$$

The firm's technical efficiency (TE_i) represents the ratio of observed output to maximum feasible output and lies between 0 and 1. TE_i is considered to be non-negative since the firm's output is assumed to be positive. If TE_i is equal to 1, then the firms employ all of their inputs efficiently and achieve an optimal output. If it is less than 1, the firms experience a degree of inefficiency in their production. It is assumed that technical efficiency is a stochastic variable with a distribution common to all firms and can be written as in equation (4).

$$TE_i = \exp(-u_i). \tag{4}$$

But $0 \leq TE_i \leq 1$, therefore, $u_i \geq 0$. Again, a firm's output level is subject to various random shocks that include anything from bad weather to unexpected luck and these effects are denoted as exp (v_i). Thus, the production function is further expanded as in Equation (5).

$$y_i = f(x_i;\beta) \cdot \exp(-u_i) \cdot \exp(v_i). \tag{5}$$

After taking the natural log of both sides Equation (6) is obtained.

$$\ln y = \beta_0 + \sum_{j=1}^{K} \beta_i \ln x_i + v_i - u_i, \tag{6}$$

Where, *j* refers to all firms from the first to the last (k). In this general specification, v_i is a pure noise component and a two-sided normally distributed variable, while ui is the non-negative technical inefficiency component. Both terms form a compound error term with an apriori unknown distribution. The model is estimated by maximum likelihood assuming a log-quadratic production function that encompasses either the Cobb-Douglas or Translog specification.

Thus, having obtained the parameters of the production function for the firms, [6] used them to obtain the technical efficiency score of firms by expressing the actual output level as a percentage or fraction of the potential maximum output after which a mean technical efficiency is obtained. The technical efficiency is calculated as indicated in equation (7).

$$\mathrm{TE_i} = \frac{y_i}{y_i^*} = \frac{\mathrm{y_i}}{\exp(\mathrm{x_{i,}}\beta)_*} = \exp(-\mathrm{u_i}), \quad (7)$$

Where y_i is the actual mean output level of firms, $y_i^* = \exp(x_{i,}\beta)^*$ is the potential mean maximum output level of the firms and (–u) is as defined before.

2.2 Production function

A production function shows the functional relationship between the quantity of a specific product that can be produced within a time and a set of inputs used, given the existing technology in a socio-cultural environment [7]. Production function could be applied as a barometer for finding out what magnitude of increase in output over time is attributable to increases in the inputs of production, the existence of returns to scale and technical progress. The traditional theory of production function of the firm expresses output (Q) as a function of typically two inputs, thus; capital (K) and labour (L) in the forms of the Cob-Douglas or Translog functions as;

$$Q = f(K, L), \quad (8)$$

2.3 Cobb-Douglas production function

The traditional Cobb-Douglas production functional form with two factor inputs is stated as;

$$Q = AO\, L^{\alpha}{}_t\, K^{\beta}{}_t \quad (9)$$

$$\text{Or } \ln Q = \ln A_O + \alpha \ln L + \beta \ln k \quad (10)$$

Where Ao is a scale parameter, Q is the level of output, α is the elasticity of output with respect to labour and β is the elasticity of output with respect to capital. The sum of α and β (α + β) gives the magnitude of homogeneity of the function which is also an indicator of returns to scale parameter. If the sum of the two is greater than unity, the function is said to be exhibiting increasing returns to scale. If it is however, less than unity it exhibits decreasing returns to scale and if it is just equal to unity it shows constant returns to scale. Originally, Cobb and Douglas assumed returns to scale to be constant which means the sum of the elasticities is always equal to unity. The Cobb-Douglas production function is based on the assumption that the elasticity of substitution of labour for capital is equal to one in the production of all commodities. This is seen as a major weakness of the model since it tends to restrain the model from measuring the existence of factor intensity reversal. However, in spite of the inherent weakness associated with the Cobb-Douglas model, it has been intensively applied in quite a number of empirical research works such as one by [8] on health services efficiency in the United Kingdom (UK) and [9] on the United States of America's census of manufacturing.

2.4 Translog production function

The transcendental logarithmic production function also called the Translog production function was developed by [10]. They approximated the logarithm of output by a quadratic form in the logarithm of two inputs as;

$$\ln Q = b_O + b_K \ln K + b_L \ln L + 1/2 b_{kk}(\ln K)^2 + 1/2 b_{LL}(\ln L)^2 + b_{LK} \ln K \ln L \quad (11)$$

Where Q is the gross manufacturing output, K is real stock of capital input, L is labour input, bo is the intercept or the constant term, b_L and b_k are first order derivatives, b_{LL} and b_{kk} are own second order derivatives and b_{Lk} is a cross second order derivative. The advantage of this production function is that it is easily estimated as compared to the Cobb-Douglas production function. As a Taylor second-order approximation to any production function, it can be used for the verification of whether or not the coefficient of the elasticity of substitution of factor inputs is variable. In the case of a three-factor inputs situation; capital (K), labour (L) and material (M). Thus, Equation (11) can be reformulated as in Equation (12);

$$\ln Q = b_o + b_k \ln K + b_L \ln L + b_M \ln M + 1/2 b_{kk}(\ln K)^2 + 1/2 b_{LL}(\ln L)^2 + 1/2 b_{MM}(\ln M)^2 + b_{LK} \ln K \ln L + b_{LM} \ln M \ln L + b_{kM} \ln K \ln M \quad (12)$$

Where, variables are as defined before with bMM as own second order derivative and b_{LM} and bKM as cross second order derivatives. This function is relatively a more flexible form of production function which takes account of the shortcomings of the Cobb-Douglas production function by permitting the partial elasticities of substitution between inputs to vary. The elasticity of scale can vary with output and factor proportions, permitting its long run average cost curve to take the traditional U-shape. The properties of this production function make it superior over that of the Cob-Douglas and others.

3. Methodology

3.1 Study area

The area for this study covers the country of Ghana, located in the West African sub-region and shares boundaries with Togo to the east, Ivory Coast to the west and Burkina Faso to the north. The Atlantic Ocean is located at the south of the country. The 2010 census results indicate that Ghana has a population size of about 24 million. The main stay of economic activities in the country is agriculture employing about 60% of the country's labour force with the industry and services employing the remaining 40% [11]. It is located 8^0N; 2^0W on the world's map. The pharmaceutical manufacturing sub-sector of the Ghanaian economy employs about 3.5% of the industrial labour force of the country. About 80% of the pharmaceutical manufacturing firms in the country are located in the greater Accra region particularly in the Accra-Tema area which is the industrial and commercial centre of the country. The remaining firms are located in the Eastern, Brong Ahafo and Ashanti regions.

3.2 Study design

Survey design is chosen for this work. Cross-sectional survey data from the pharmaceutical manufacturing firms in Ghana in 2015 are used for the research analysis. The main strength of this research design lies in the fact that it encourages direct communication between the researcher and the targeted respondents in the course of the collection of data needed for the study. Again, the use of the survey design for micro-data is more efficient compared to the other forms of design since it has an advantage of solving several problems relating to estimation and aggregation of data collected from the primary source [12].

3.3 Population for the study

Population used for this research work is the pharmaceutical manufacturing firms in Ghana. The choice of this population is informed by the fact that the estimation of technical efficiency of firms is based on the fundamental assumption that the production units under consideration produce the same product(s) to justify the basis of comparison made from the data analysis. Firms in the pharmaceutical manufacturing industry produce pharmaceutical products which are respectively the same but differentiated by branding and trademarks. Again, firms in the industry use the same forms of technology even though they may differ in terms of levels.

According to the data obtained from the Food and Drugs Board (FDB) now called the Food and Drugs Authority (FDA) of Ghana, there were 39 pharmaceutical manufacturing active firms in the country as at the time of this research work (even though the registered number was 48). These firms were made up of 18 foreign-owned firms representing 46% and 21 domestic-owned firms representing 54%. The pharmaceutical manufacturing firms in Ghana are with different capacities and qualities with 8 of them being small scale, 32 medium scale and 8 large scale ones. All these firms produce generic drugs which could be technically classified into tablets, capsules and syrups.

3.4 Sample and sampling procedure

Considering the fact that the total number of pharmaceutical manufacturing firms in Ghana was just 39, the population of the entire industry was used for the study. This became imperative because using a portion of the population as a sample for the study would not produce any statistically meaningful and reliable result from the study. Furthermore, using the entire population for the study would make the findings most reflective of the reality on the ground and reliable for any purpose. Thus, all the 18 foreign-owned firms and 21 domestic-owned firms were used for the study.

3.5 Source and type of data collection

The fact that pharmaceutical manufacturing firms characteristically produce a wide range of varied finished products and to make the handling of such a situation feasible for this work, the products were classified into three major descriptions namely, tablets, capsules and syrups. Thus, finished pharmaceutical products in the forms of bottled-powder or powder in sachets, all forms of liquids, ointments and suspensions for example were classified as syrups. All forms of pills for oral dosage or otherwise were classified as tablets and all forms of shelled powder were grouped as capsules. In this respect, a given firm had three output levels including output of tablets, output of capsules and output of syrups in 2015. Tablets and capsules are measured in packs whilst syrups are measured in litres. From a factory definition, a pack is made up of 100 sachets of 100 milligrams of tablets or capsules particularly packed in a box. A litre of syrup is the equivalent of 1,000 millilitres of syrup.

Inputs used by firms included labour which is made up of skilled and unskilled expressed in man-hour units. Skilled labour included highly trained workers called technicians at the factories and the management teams of the firms. Unskilled labour refers to workers with no specific training like cleaners and porters. Capital used by firms was mainly made up of engine powered equipments (plants) which came in some varied forms depending on the sizes of the respective firms. The current cost of a plant of a firm was considered for use in the data instead of the physical unit of the plant. It must be noted that the main plant considered for the study was the 'crush plant' of a firm which was seen as the plant that determined the final output of a firm in all the three products and not the finisher peripheral small plant which were used for product branding.

Raw materials used by the firms were predominantly imported with a few ones obtained domestically. The major imported raw materials included chemicals of different varieties and volumes while the domestic ones included brown-paper curtains, labels, bottles and water. The local raw materials were substantially less expensive as compared to the imported ones. Once again, the expenditures made on the raw materials (in Ghana cedis) were considered for the estimation and not the physical units.

4. Model specification

With reference to Equation (6) a specification of a production functional form upon which the stochastic frontier analysis will be based is constructed. This will lead to the estimation of the parameters of variables with the use of the Frontier version 4.1 software developed by [13].

4.1 Appropriate production functional form

In determining whether the stochastic frontier production function was of Cobb-Douglas or translog form in order to ensure statistical consistency in the estimation, two steps of testing were applied. First, a regression for firms' data was run separately with the two production functional forms. It was conclusively observed that the Cobb-Douglas production function was a better option. This is because it produced a normal production curve for the data. The Translog production function was rejected because it produced a non-concave production curve indicating that it was not appropriate for the data. It also meant that there were no interactive terms among the input factors of the data hence, the choice of the Cobb-Douglas form. After this, the Cobb-Douglas production function was restricted and subjected to log-likelihood test as has been used in literature by several researchers like [12,14]. This test is done with the null hypothesis that the frontier production function is not of Cobb-Douglas form. The test is explained on Tables 1and 2 for both firm groups.

4.2 Log Likelihood Test

The log-likelihood test based on the assumption of null hypothesis (Ho) which is a restriction that the frontier production function is not of Cobb-Douglas form, hence, ($H0: \beta_0 = \beta_1 = \beta_2 = 0$) indicates that all the parameters will be equal to zero if applied. With 5 degrees of freedom, the chi-square distribution on Tables 1 and 2 at 95% is 0.7107. All the log likelihood estimates from the stochastic frontier production function for the three products in each firm group fall outside this critical value. Thus, the log-likelihood values are significant given their respective probability values as significantly less than 1% (i. e. 0.0000). We therefore, fail to accept the null hypothesis that the frontier production function is not of Cobb-Douglas form. The Cobb-Douglas production form is thus, used for the estimation as shown with Equation (13).

Table 1: Log likelihood test for foreign-owned firms' model

Null Hypothesis	Log Likelihood value	Df	P value	Decision
$H_O: \beta_0 = \beta_1 = \beta_2 = 0$ (Tablets)	14.4454	4	0.0000	Rejected
$H_O: \beta_0 = \beta_1 = \beta_2 = 0$ (Capsules)	14.7176	4	0.0000	Rejected
$H_O: \beta_0 = \beta_1 = \beta_2 = 0$ (Syrups)	10.9054	4	0.0000	Rejected

Test statistic: ($\chi^2_{5,0.95}$) = 0.7107

Table 2: Log likelihood test for domestic-owned firms' model

Null hypothesis	Log likelihood value	df	P value	Decision
$H_O: \beta_0 = \beta_1 = \beta_2 = 0$ (Tablets)	15.6656	5	0.0000	Reject
$H_O: \beta_0 = \beta_1 = \beta_2 = 0$ (Capsules)	15.6827	5	0.0000	Reject
$H_O: \beta_0 = \beta_1 = \beta_2 = 0$ (Syrups)	19.1814	5	0.0000	Reject

Test statistic: ($\chi^2_{5,0.95}$) = 0.7107

$$\ln Y_{gi} = \beta_{0g} + \beta_{1g}\ln sl_{gi} + \beta_{2g}\ln ul_{gi} + \beta_{3g}\ln k_{gi} + \beta_{4g}\ln M_{gi} + v_{gi} + u_{i.} \quad (13)$$

Where, *ln* is natural logarithm (that is log to base *e*, where e = 2.718). Y represents the mean output level for the firms for each of the three products in the year under consideration. Output is defined in terms of (a) tablets; for all forms of tablets produced by firms during the period; (b) capsules; for all forms of shelled powdered chemical product produced by firms during the period; and (c) syrups; for all forms of powdered and liquid chemical product produced during the period; *gi* denotes the i^{th} firm and *sl* denotes skilled labour used by firms in terms of man-hours, *ul* denotes unskilled labour used by firms in terms of man-hours, k denotes values of physical capital used by firms, M denotes other inputs (raw materials) used in production by firms, *v* is a two-sided error term assumed to be identically and independently distributed, u is a non-negative technical inefficiency component of the error term and *βs* are parameters to be estimated.

4.3 Technical Efficiency levels of Firms

In estimating the technical efficiency levels of the two firm groups separately, the respective production parameters so obtained from the stochastic frontier Cobb-Douglas production function (with Equation 13) are first expressed as a fraction of the potential output levels of the firms to predict the technical efficiency score for each product by each of the firm groups using the conditional expectation of Equation (14). After that, an average value of technical efficiency from each firm group is obtained as a grand technical efficiency level. Each technical efficiency score is multiplied by 100 to convert them into percentages.

$$\mathrm{TE_{gi}} = \frac{\mathrm{Y_i}}{e^{\beta_{0g}} \quad + \beta_{1g}\ln sl_{gi} + \beta_{2g}\ln ul_{gi} + \beta_{3g}\ln k_{gi} + \beta_{4g}\ln M_{gi} + v_{gi} + u_{gi}} = e^{-u_{gi}} \tag{14}$$

Now, using the composed error term (u_i) of the stochastic frontier production function model in equation (14), the variation in actual output from the frontier output level is partially attributed to technical inefficiency defined by Equations (15 a) and (15b).

$$\sigma^2 = (\sigma_u^2 + \sigma_v^2) \tag{15a}$$

$$\gamma = \sigma_u^2/(\sigma_u^2 + \sigma_v^2) = \sigma_u^2/\sigma^2 \tag{15b}$$

That is, the parameter $\gamma = \sigma_u^2/\sigma^2$ is the proportion of the variance of technical inefficiency in the entire error variance. Where, σ^2 is as defined before and γ is the measure of technical inefficiency for firms.

5. Results and discussion

5.1 Descriptive Statistics of Variables

Table 3 illustrates the mean and standard deviation values of the variables used for the study to find out their behaviours for the two firm groups. It is observed from Table 3 that with the exception of skilled and unskilled labour (man-hour), foreign-owned firms had greater averages in all the variables used in the estimation of the stochastic frontier analysis. In the case of output levels of the three products under consideration, foreign-owned firms produced greater output in each product than the domestic-owned firms did. This can be attributed to the fact that they invested more in raw materials during the period. The foreign-owned firms invested an average of GHC 855 000 on raw materials as compared to GHC 736 000 by the domestic-owned firms. The greatest difference in output is found with syrups production. While foreign-owned firms produced about 6.4 million litres on the average, the domestic-owned firms produced about 4.8 million litres during the period.

Table 3: Average values of variables

Variable	**Description**	**Domestic-owned firms**		**Foreign-owned firms**	
Production function		**Mean**	**St. Deviation**	**Mean**	**St. Deviation**
Ln (Y)	1.Tablets in packs	5 500 000	4 502960	6 610 000	3 671 100
	2. Capsules in packs	5 300 000	4274 760	6 060 000	3 750 480
	3. Syrups in litres	4 804 000	3733 780	6 425 000	4 442 130
ln (K)	Capital in thousands of cedis (GHC)	2 400	2 256	3700	1 722
ln (SL)	Skilled labour in man-hours	153 130	134 210	148 030	85 800
Ln (UL)	Unskilled labour in man-hours	50 130	43 810	38 210	27 400
ln (M)	Raw materials used in thousands of cedis (GHC)	736	709	855	565

Source: survey data, 2010

5.2 Estimation of Input Parameters

The parameters of input coefficients and the associated variances obtained from the maximum likelihood estimation using the Cobb-Douglas stochastic frontier production model with reference to equation 13 are presented on Tables 4 and 5. They indicate the difference between the foreign-owned and domestic-owned firms in terms of the magnitude of the parameters and their significance in the use of inputs during the period under consideration. In line with literature, variables used in the function include capital, labour (skilled and unskilled), and raw materials used by firms in each group. The data on foreign-owned firms are considered first on Table 4. Since the Cobb-Douglas production function used in the estimation process is a double log model, the estimated parameters can be interpreted as elasticities. Table 4 indicates the stochastic production frontier results for tablets, capsules and syrups and it shows that capital, labour and raw materials influenced outputs of these products significantly in the case of foreign-owned firms. The estimated parameters for capital are 0.7621, 0.8726 and 0.6380 and are significant at 5%, 5% and 1% significance levels in the production of tablets, capsules and syrups respectively. Those for skilled labour are -0.1202, -0.1610 and 0.5764 significant at 10%, 5% and 10% levels in the production of tablets, capsules and syrups respectively. Those for unskilled labour which are not significant are -0.0121, -0.0321 and 0.0423 respectively in the production of tablets, capsules and syrups respectively.

Table 4: Estimation of stochastic frontier production models for tablets, capsules and syrups by foreign-owned firms

Variable	*Parameters*	*Tablets*	*Capsules*	*Syrups*
Constant	β_0	0.5672^{***} (0.2317)	0.8980^{**} (0.1290)	0.3480^{*} (0.6280)
ln K	β_1	0.7621^{**} (0.3412)	0.8726^{**} (0.4051)	0.6380^{***} (0.5020)
$ln(SL)$	β_2	-0.1202^{*} (0.0290)	-0.1610^{**} (-0.1024)	0.5764^{*} (0.0340)
$ln(UL)$	β_3	-0.0121 (0.0012)	-0.0321 (0.0033)	0.0423 (0.0056)
ln M	β_4	1.056^{*} (0.2710)	1.033^{***} (0.1258)	1.400^{**} (0.0529)
Variance parameters				
Lambda $(\frac{\sigma_u}{\sigma_v})$	λ	1.5203	1.5579	1.403
Sigma	σ	0.8642 (0.1452)	0.9682 (0.2541)	0.9424 (0.2570)
Sigma − squared (u)	σ_u^2	0.6806 (0.1822)	0.7451 (0.5124)	0.7011 (0.3251)
Sigma − squared (v)	σ_v^2	0.1836 (0.3982)	0.1922 (0.7512)	0.1871 (0.9654)
Log likelihood		14.4450	14.7166	10.9044
Gamma (γ)	$\sigma_u^2/(\sigma_u^2+\sigma_v^2) - \pi r^2$	0.5171 (0.1822)	0.5951 (0.5632	0.5292 (0.9512)

Source: Computed from survey data, 2015

Note: *, ** and *** denote significance at 10%, 5% and 1% levels respectively

The parameters of raw materials are 1.056, 1.033 and 1.400 significant at 10%, 1% and 5% respectively in the production of the three products in that order. Since each of the parameters is less than one except those of raw materials, output of each of the products is less responsive to capital and labour. However, in relative terms, they are more responsive to capital than to both skilled and unskilled labour. However, raw material's parameters are each greater than one in each of the products. This means output is more proportionately responsive to raw material in each of the products. It must be noted that since the coefficient values of unskilled labour are insignificant, output levels of the products statistically do not respond to this input. Capital is said to have greater impact on output of each of the products. This is supported by the finding of [15] which concluded that foreign-owned firms in the US were more productive with capital having greater impact on output. On the contrary, [16] in their study in Canada concluded that foreign-owned firms enjoyed higher output response to labour than it was the case with capital. This means that if employed capital increases by 10%, output in tablets, capsules and syrups will increase by about 8%, 9% and 6% respectively. If raw materials employed increase by 10%, output of tablets, capsules and syrups will increase by 1%, 6% and 1% respectively. On the other hand, if skilled labour increases by 10%, output levels in tablets and capsules will decrease by 1% and 2% respectively but that of syrups will increase by 6%. It implies that there is over-deepening of skilled labour employment in the production of tablets and capsules. As a result, output levels of these products would be increased if the employment level of skilled labour is reduced. These observations mean that foreign-owned firms tend to rely more on capital than labour in their production activities. Again, it can be observed from Table 4 that the values of lambda (λ) and sigma (σ) in each of the estimates of the three products are large and significantly greater than zero.

This approves the correctness of the specified distribution assumption of the study (i.e., $e_i = v_i + ui$). Lambda (λ) is the ratio of variance of (σ_u) and variance of (σ_v) and given its value in the results of each of the products as 1.5203, 1.5579 and 1.4301 respectively, it indicates that the one-sided error term 'u' dominates the symmetric error term v, hence, variations in actual group outputs are attributed to differences in firms' practices rather than random variability. Furthermore, gamma (γ) is also a measure of level of inefficiency in the variance parameter ranging between 0 and 1. For tablets, gamma is estimated at 0.5171. This shows that about 52% of random variation in tablets production is explained by inefficiency among foreign-owned firms. In the case of capsules and syrups productions, gamma values are 0.5951 and 0.5292 respectively implying that about 60% and 53% of random variations are respectively explained by inefficiency among foreign-owned firms.

Table 5 indicates similar parameters in the case of domestic-owned firms. It also shows that capital, skilled labour and raw materials individually explains outputs of the products by domestic-owned firms significantly at the respective significance levels of between 1% and 10%. The estimated parameters for capital are 0.3659, 0.1675 and -0.1013. These are significant at 1 %, 5% and 10% levels respectively in the production of tablets, capsules and syrups. Skilled labour's parameters are 0.6554, 0.6125 and 0.7384 and are significant at 10%, 5% and 1% respectively. Once again, it is realized that the parameters of unskilled labour are insignificant in all the three products. Since each of the parameters with respect to capital and skilled labour is less than one, output of each of the products is less responsive to the respective inputs. However, in relative terms, they are more responsive to skilled labour than capital. In other words, skilled labour is said to have greater impact on output of each of the three products. The implication is that if capital increases by 10%, output in tablets and capsules will increase by about 4% and 2% respectively but output in syrups will fall by about 1%.

On the other hand, if skilled labour increases by 10%, output levels in tablets, capsules and syrups will increase by about 7%, 6% and 7% respectively. This affirms the finding of a research work by [17] in Venezuela that domestic-owned firms in the plastic industry depended mostly on their labour input more than capital in increasing output levels per unit time in production. Similarly, it is observed from Table 5 that the data are distributed in line with the specified assumption that $e_i = v_i + u_i$. It is also clear that like the situation with the foreign-owned firms, raw material parameter in each case is greater than one implying that the outputs of the products were all responsive to raw material input. Thus, a 1% increase in raw material leads to a greater proportionate increase in outputs of the products.

Table 5: Estimation of stochastic frontier production model for tablets, capsules andsyrups by domestic-owned firms

Variable .	Parameters	Tablets	Capsules	Syrups
Constant	β_0	0.3107* (0.8452)	0.4432*** (0.1125)	0.9015* (0.2342)
ln K	β_1	0.3659*** (0.1210)	0.1675** (0.0500)	-0.1013* (0.1402)
ln (SL)	β_2	0.6554* (0.1608)	0.6125** (0.1204)	0.7384*** (0.2454)
ln(UL)	β_3	0.1023 (0.057)	0.2012 (0.3053)	0.3210 (0.2220)
ln M	β_4	1.0009** (0.1627)	1.0050** (0.1778)	1.0200** (0.2222)
Variance parameters				
Lambda ($\frac{\sigma_u}{\sigma_v}$)	(λ)	1.7041	1.6258	1.8395
Sigma	(σ)	0.3886 (1.3051)	0.4994 (1.7349)	0.2540 (0.6275)
Sigma − squared (u)	σ_u^2	0.8281 (1.2945)	0.7878 (1.7133)	0.8354 (0.4361)
Sigma − squared (v)	σ_v^2	0.2114 (0.0786)	0.2606 (0.8126)	0.1774 (0.2155)
Log likelihood		15.4453	15.6827	9.1814
Gamma (γ)	$\sigma_u^2/(\sigma_u^2 + \sigma_v^2)$	0.6855	0.7405	0.8068

Source: computed from survey data, 2015

Note: *, ** and *** denote significance at 10%, 5% and 1% levels respectively

The values of gamma for the various products indicate the proportion of inefficiency in the error term in the production of the respective products and these are 0.6855, 0.7405 and 0.8068 for tablets, capsules and syrups productions respectively. Thus, about 69%, 74% and 81% of random variations in the production of tablets, capsules and syrups are respectively explained by inefficiency among domestic-owned firms. It can be observed from Tables 4 that with the foreign-owned firms, just 52%, 60% and 53% of random variations in production of tablets, capsules and syrups respectively are attributed to inefficiency. The interpretation is that the proportion of output shortfall is greatly attributable to domestic-owned firms' inefficiency whilst a small proportion is due to distributional error. Comparatively, the portion of output shortfall attributable to inefficiency in the case of foreign-owned firms is smaller relatively. This finding is in agreement with the finding of [18] in China which concluded that there were comparatively larger inefficiency levels among the Chinese local firms in the rice production industry ranging between 65% and 73% of their mean error term. It is however, in contrast with the finding of [19] which indicated that inefficiency levels among foreign-owned firms were rather greater than those of domestic-owned firms in Ghana.

5.3 Scores of mean technical efficiency of firms

Tables 6 and 7 illustrate the mean technical efficiency scores for the three products from each firm group obtained from Equation (14). As noted in the methodology section, the technical efficiency score of a group for a product is between 0 and 1. Secondly, the mean, standard deviation, maximum and minimum technical efficiency scores are estimated separately for each of the two firm groups in the production of each of the products.

Table 6: Product mean technical efficiency levels for domestic-owned firms

Product	**No. of Firms**	**Mean (%)**	**St. Dev. (%)**	**Maximum (%)**	**Minimum (%)**
Tablets	21	54.50	44.50	70.55	35.49
Syrups	21	60.00	45.00	81.05	43.00
Capsules	21	55.42	53.60	73.55	42.50

t-ratio for testing equality of mean: 2.17**

It is observed from Table 6 that domestic-owned firms are more technically efficient in syrups production with the mean score of technical efficiency as 60% ranging between about 81% and 43%. Relatively, they are least technically efficient in tablet production with efficiency score about of 54.50%. In fact, approximately, firms in this group are equally efficient in the production of both tablets and capsules with an approximated value of about 55%.

Table 7: Product mean technical efficiency levels for foreign-owned firms

Product	No. of Firms	Mean (%)	St. Dev. (%)	Maximum (%)	Minimum (%)
Tablets	18	78.60	17.50	93.90	49.10
Syrups	18	50.00	21.20	78.80	42.60
Capsules	18	68.50	19.50	93.10	49.30

t-ratio for testing equality of mean: 2.17**

On the other hand, Table 7 shows that foreign-owned firms are most technically efficient in the production of tablet with the highest mean score of about 79% ranging between about 94% and 49%. Their next efficiency level is in the production of capsules scoring about 69% ranging between about 93% and 49%. It can also be observed that the standard deviation values of the mean scores of domestic-owned firms range between about 45% and 54% compared to the case of foreign-owned firms which range between about 18% and 20%. This shows that the individual efficiency scores of firms in the domestic-owned group are well dispersed from their overall mean score compared to the case of foreign-owned firm group. Thus, the mean score value of the foreign-owned firms is more fitting and reliable compared to that of the domestic-owned firms.

Table 8 indicates the grand technical efficiency mean scores of the two groups of firms. It shows the overall or grand average score of the three products for each firm group in the case of mean, standard deviation, maximum and minimum technical efficiency scores. It is observed that the mean technical efficiency score for domestic-owned firms in producing the three products range between about 75% and 40% whilst those for foreign-owned firms are between about 89% and 47%. The mean technical efficiency score for foreign-owned firms in the production of the products is about 66% and that of domestic-owned firms is about 57%. These scores are significant at 5% level (one-tail test).

Table 8: Overall or Grand Mean Technical efficiency levels of foreign-owned and domestic-owned firms

Firm group	No. of firms	Mean (%)	St. Dev (%)	Maximum (%)	Minimum (%)
Domestic-owned Firms	21	56.64	47.70	75.05	40.33
Foreign-owned firms	18	65.70	19.40	88.60	47.00

t-ratio for testing equality of means: 2.17**

Source: computed from survey, 2015

Note:- The t-ratio is for testing of equality of means done under the assumption of unequal variance, ** shows statistic significance at 5% level (one tail test)

Thus, it is clear that foreign-owned pharmaceutical manufacturing firms in Ghana are on the average more technically efficient than their counterpart domestic-owned ones in the industry. The implication is that, the foreign-owned firms are relatively closer to their frontier (potential output level) than the domestic-owned firms are to theirs. This is contrary to the findings of [14] and [19] in their respective studies in Ghana which concluded that foreign-owned firms were less efficient as compared to the domestic-owned firms. This finding could be attributed to the fact that whilst this study used only firms that produced the same products with the same forms of technology, the other studies used firms that produced entirely different products with different forms of technology. Thus, as was explained by [20], the fact that they did not consider the heterogeneity of technology used in production by the respondent firms could lead to underestimation or overestimation of efficiency scores. However, many studies in literature conclude that foreign-owned firms are more technically efficient than domestic-owned firms. Some of such studies are those by [21] and [22].

6. Summary, Conclusions and Recommendations

6.1 Summary

The purpose of this study was to investigate the perceived problem of technical inefficiency among domestic-owned pharmaceutical manufacturing firms in Ghana. Considering the total number of pharmaceutical manufacturing firms in country, the entire population of firms in the industry numbering 39 was used for the study. The questionnaire instrument was used for data collection for the study. Data on firms' inputs for production and their respective outputs were collected. A two-staged procedure was applied in analysing the data collected for the study. The first one employed the Cobb-Douglas stochastic frontier production to find the parameters of inputs used by firms in producing tablets, capsules and syrups. Secondly, the obtained parameters were used to predict the mean technical efficiency levels for the two firm groups after finding the respective product technical efficiency means for each of the groups using the three products.

6.2 Conclusions

With reference to the stated objectives of the study, the following conclusions are drawn. Firstly, mean technical efficiency levels for the two firm groups were predicted with their respective input parameters in relation to their respective outputs. It is concluded that foreign-owned firms had higher mean technical efficiency level in production. Thus, in agreement with literature, foreign-owned pharmaceutical manufacturing firms are more technically efficient than domestic-owned pharmaceutical manufacturing firms. By extension, it is generally concluded that, foreign-owned firms in Ghana are more efficient than domestic-owned ones. In the same vein, it is observed that even though levels of inefficiency were found in each of the two firm groups, domestic-owned firms had a higher level of inefficiency on the average.

Secondly, it is realised that impacts of capital on output levels of the three products in the case of foreign-owned firms were greater than the impacts of their labour on output levels. On the other hand, the impacts of labour on output levels of the three products in the case of domestic-owned firms were greater than the impacts of their capital on output levels. This implies that output levels of foreign-owned pharmaceutical manufacturing firms are more responsive to capital than to labour but those of domestic-owned pharmaceutical manufacturing firms are more responsive to labour than to capital.

The research findings support the theoretical literature position that foreign-owned firms are more technically efficient than domestic-owned firms. It can be concluded from the results of the study that pharmaceutical manufacturing firms whose output levels are more responsive to capital tend to operate closer to their frontier and for that matter are more technically efficient than those whose output levels are more responsive to labour than to capital.

The findings of the study actually substantiate the perception held that the problem of technical inefficiency among firms in Ghana is linked to ownership. The findings also serves as a ground for understanding the rationale behind Ghana government's decision of selling most of its enterprises to foreign investors during the privatization programme under SAP in the late 1990s and the decision to promotion of FDI in the country. Hence, the original problem of the study is better understood.

6.3 Recommendations

Taking inspirations from the findings of the study, recommendations are made to the relevant institutions and the managements of the domestic-owned pharmaceutical manufacturing firms and other firms in general in Ghana. It is recommended to the Ghana Investment Promotion Centre (GIPC) to intensify its promotion of foreign direct investment especially, in the pharmaceutical manufacturing in the country. This will have the tendency to increase output levels in the manufacturing industry and the economy as a whole to boost economic growth. Thus, government's revenue from company tax will also increase and this could be used for national development.

It is also recommended to the Pharmaceutical Manufacturing Association of Ghana (PMAG) and in general the Association of Ghana Industries (AGI) to encourage their members to enter into joint venture direct production activities with their foreign counterpart investors in the country. This will pave the way for a sustained transfer of technical efficiency-related skills, knowledge and technology from the foreign investors to local producers. Consequently, horizontal and vertical linkages can take place in the manufaturing industry in particular and the economy as a whole. This will also go a long way to improving upon the level of technical efficiency in production by the domestic-owned firms and the economy will stand to benefit further.

6.4 Area for Further Research

It was realized during the literature review that a few research works had been done in Ghana on technical efficiency with the stochastic frontier approach. Such few works concentrated on the industrial sector only. However, as a developing country, Ghana's economy is mainly dependent on the agricultural sector, particularly the cocoa production sector. In this respect, government introduced the nationwide free spraying of cocoa farms in 2001 to help improve on technology in cocoa production in the country so as to increase output level in the industry. It is therefore recommended that a future study is done in the cocoa production industry impact assessment on technical efficiency level in the industry before and after the exercise. The findings of such a study will help to identify some of the pertinent drawbacks in the sector in terms of technical efficiency for redress by the appropriate ministry. When this is done, a further boost will be given to the cocoa industry to increase output level to the benefit of the economy as a whole.

6.5 Constraint to the study

The major constraint to this study was accessibility to total reflective data with regards to inputs used by the pharmaceutical manufacturing firms and their output data in Ghana. Some of the major players involved in the provision of these data were quite reluctant to release them for the study. Out of traditional belief, some of these officers treat such data as classified to their operations with the suspicion that when released, would expose their businesses to higher corporate taxes to the authorities. Against this backdrop, it is suspected that quite a few of the data released by such firms through their respective officers were doctored and may not reflect the true picture of their operations. Since the findings of the study are by and large influenced by such few data, it could be suspected that they may not be totally perfect and may be applied with some degree of caution.

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