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Foreign Capital and Firm Level Efficiency in Ghana: A Metafrontier Production Function Approach

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ABSTRACT

The role of foreign human and physical capital in the productive efficiency of the manufacturing firms in Ghana is examined in this thesis. We compare efficiency scores of two groups of firms- firms with foreign presence and local firms- that have heterogeneous technology. A Stochastic Metafrontier production function, which accommodates differences in technology, is estimated. The estimated technical efficiencies indicate that manufacturing firms in Ghana are generally less efficient. Although firms with foreign presence had higher mean value added figures relative to the local firms, the local firms were found to be more efficient and also closer to the potential output defined by the metafrontier function compared to the firms with foreign presence. We also find technical efficiency to be influenced by firm size, food producing firms, profits and firms located in the capital city (Accra). Moreover, our results show that physical capital is more productive in the local firms, which implies that (foreign) physical capital to local manufacturing firms in Ghana is more important than foreign human capital.

Key-words: Metafrontier, Technology, Efficiency, Foreign capital

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1.0 INTRODUCTION

1.1 Background

From independence in 1957, Ghana adopted an import substitution industrialization strategy centered on the promotion of large scale, capital-intensive manufacturing enterprises (Dinye and Nyaba 2001). Complete plants were imported for the establishment and operation of a wide range of state-owned manufacturing enterprises, which included food processing, textiles, wood products, furniture, metal and machinery to mention just a few. Until 1983, these industries were protected from foreign competition through a restrictive trade policy regime complemented by an array of subsidies serving as incentives. Trade policy instruments include quantitative import restriction, foreign exchange rationing, high tariffs on imported consumer goods, import licensing and domestic price controls (Dinye and Nyaba, 2001). The heavy protection and subsidization did not help the manufacturing firms. That is, the government's protection and subsidization of Ghanaian manufacturing firms made them non competitive hence inefficient. This argument is consistent with a study by Wade (1990) that the use of the state to promote import-substitution industrialization during the 1950s and 1960s had resulted in inefficient industries requiring permanent subsidization with little prospect of achieving international competitiveness. For instance, the share of manufacturing in the total industrial output grew from 10% in 1960s to 14% in 1970 but declined from 11% in 1971 to 3% in 1983[1].

In order to improve the situation, as described above, the government in 1983 with the assistance of the World Bank and International Monetary Fund (IMF) embarked on a program of comprehensive economic recovery dubbed Economic Recovery Program (ERP) and Structural Adjustment Program (SAP). The period 1983 to 1991 saw the implementation of a number of policies and programs including the privatization of State-Owned Enterprises (SOEs). Within the ERP, some manufacturing firms received foreign assistance

[1] United Nations Industrial Development Organization (UNIDO), Regional and Country Studies Branch, Industrial Development Review Series – Ghana, Vienna (1986).

in the form of human capital and physical capital to enable them build their capacities and enhance their technical efficiencies. While some of the SOEs were fully sold to both foreign and local investors, others were partially divested, the objective of which is to increase efficiency (Akuete, 1992). By 1986 the ownership structure of Ghanaian Enterprises was as follows: 9% was wholly foreign owned, 39% was jointly owned by foreign investors and local entrepreneurs, 22% represented state–local private ventures and 30% was wholly state owned[2]. During 1989 –1996, out of 193 Ghanaian enterprises that were sold, 52% were industrial establishments, and total sales of firms to foreigners were 71%[3]. It is commonly asserted that foreign presence in firms in developing countries enhances efficiency. In contrast Teal et al (2003) reported that technical inefficiency is not lower in firms with foreign ownership and its dispersion across firms is similar to that found in other economies. Since the estimation technique used by Teal et al. (2003) did not take into account the differences in technology of the two firm categories (i.e. firms with foreign presence and local firms), we re-explore this hypothesis with Ghana as the case study.

[2] United Nations Industrial Development Organization (UNIDO), Regional and Country Studies Branch, Industrial Development Review Series – Ghana, Vienna (1986).

[3] Kayizzi-Mugerwa (2002) and Ariyo and Jerome (2003).

1.2 Problem Statement

There has been a widespread discussion about lack of adequate technical capacity in manufacturing firms in developing countries compared to their counterparts in the developed world (Söderbom and Teal 2001, 2003). Consequently, developed countries and international organizations extend both human and physical capital assistance to, mostly, manufacturing firms in developing countries, especially in Africa. It is hypothesized that these foreign capital enhances technical efficiency in manufacturing firms in developing countries.

Although a considerable amount of literature exists on the determinants of efficiency of manufacturing firms in Africa (See Söderbom 2001, Söderbom and Teal 2001, 2003, Bigsten et al 2000, Söderbom et al 2002), with particular emphasis on the role of foreign capital, current developments in stochastic frontier estimation techniques points to a flaw. Specifically, these stochastic frontier models did not accommodate the possibility of heterogeneity in technology across manufacturing firms in an industry, which may necessitate fitting the data with stochastic metafrontier production function. A likelihood ratio (LR) test shows substantial evidence in support of technology differences across manufacturing firms with and without foreign human capital, and this weakens the employment of the ordinary stochastic production function model. Our research, therefore, is the first attempt at the use of stochastic metafrontier production function to testing the impact of foreign human capital on technical efficiency and technological gaps of the manufacturing firms in Ghana. The stochastic metafrontier production function is considered to be an envelope of the stochastic frontiers of the different groups such that it is consistent with the specifications of a stochastic frontier model (Battese et al 2002). The stochastic metafrontier model also enables the estimation of technology gap ratios or productivity potentials relative to the best practice in the industry. This study adds to the literature on firm level efficiency. Our main focus is on comparing the efficiency of firms with and without foreign ownership or foreign presence (i.e. foreign human capital).

1.3 Objectives/Purpose

The main purpose of our study is to investigate whether foreign assistance to manufacturing firms in Ghana should be in the form of only physical capital or both foreign human capital and physical capital. Specific objectives are:

- Compare the technical efficiency scores of firms with foreign presence (human capital) with firms without foreign presence
- Compare technological gaps of firms with and without foreign human capital
- Identify the determinants of technical efficiency of Ghanaian manufacturing firms
- Investigate the relationship between firm size and profitability, and firm size and technical efficiency.

1.4 Thesis Outline

The rest of the thesis is organized as follows. In chapter two, we review both theoretical and empirical literature on efficiency assessment, focusing on stochastic frontier estimation techniques. Chapter three takes a look at manufacturing firms in Ghana. We present our methodology in chapter four, data analysis in chapter five and finally in chapter six, we draw conclusions and recommendations based on the results presented in chapter five.

2.0 LITERATURE REVIEW

This chapter identifies and describes the various approaches in the theoretical and empirical literature that are used to assess the efficiency of firms. The emphasis of the discussion will be on methods that are based on stochastic frontier approaches.

2.1 Theoretical Literature

In traditional economic theory, efficiency is defined as an outcome of price taking competitive behavior (Coelli et al 1998). Thus if no uncertainty is assumed, a production function is described as the maximum level of output that can be obtained from given inputs and the technology available (Kumbhaker and Lovell 2000). However, actual output may typically fall below the maximum that is technically possible. The focus of interest of many applications is the deviation of actual from maximum output, which is a measure of inefficiency.

The measurement of productive efficiency empirically is dated back to Farrell (1957). Using programming techniques, Farrell showed how to define cost efficiency and how to decompose cost efficiency into its technical and allocative components. Following his novel approach, production frontiers are used to assess the efficiency of firms. Two methods are used for the decomposition: non-parametric methods or parametric methods, which are predicted on some stochastic and non-stochastic assumptions. Both approaches (parametric and non-parametric) are used in the assessment of productive efficiency with both cross section and panel data.

The pioneering work of Farrell on efficiency measurement eventually influenced the development of data envelopment analysis (DEA), the most popular and well-established non-parametric (non-stochastic) efficiency measurement technique. DEA is a performance measurement technique, which can be used for evaluating the relative efficiency of decision-making units (DMU's) in organizations.

The parametric and stochastic approaches are econometric methods developed by various authors for the assessment of productive efficiency. These stochastic parametric methods are the stochastic frontier analysis, the stochastic frontier metaproduction, and the stochastic metafrontier approaches.

2.1.1 Stochastic Frontier Approach

In this section, the stochastic frontier production function approach to efficiency measurement is reviewed by looking at the traditional approaches as well as the most recent/modern approaches.

Traditional Approach

Aigner, Lovell, and Schmidt (1977), and Meeusen and Van der Broeck (1977) developed the stochastic composed error frontier methodology. In the formulation of the model, Aigner, Lovell, and Schmidt (1977) specified the error term equal to the sum of two parts, one normal and the other from a one sided normal distribution.

The specification of the stochastic production frontier model, allows for a non-negative random component in the error term to generate a measure of technical inefficiency or the ratio of actual to expected maximum output, given inputs and the existing technology. Apart from allowing for the measure or assessment of technical inefficiency, stochastic frontier models also acknowledge the fact that random shocks outside the control of producers can affect the output level. This is due to the fact that stochastic effects such as weather conditions among others could cause variations in maximum output. The variations in output could also occur as a result of firms in an industry operating at various levels of inefficiency due to poor incentives, mismanagement, inappropriate input levels or less than perfectly competitive behavior (Kumbhaker and Lovell 2000). In a nutshell, it assesses the impact of shocks due to stochastic effects among others on output, which could be separated from the contribution of variation in technical efficiency. The basic stochastic frontier model is specified as follows:

$$y_{it} = \alpha + x_{it}\beta + v_{it} - u_i \,,\; u_i \geq 0; i = 1,...,N; t = 1,...,T. \tag{2.1}$$

where y_{it} is the natural logarithm of the observed output for the *i*th firm, *t* indexes time periods, α is a non-random scalar intercept term, x_{it} is a vector of logarithms of inputs or functions of inputs. β is the corresponding vector of parameters to be estimated. v_{it} is a statistical noise term or measurement error and other random factors such as the effects of weather, strikes, luck, etc (Coelli et al 1998). This error term is assumed to be independently and identically distributed $N(0,\sigma^2)$ and $u_i \geq 0$ is the one-sided error term that represents technical inefficiency.

Due to the logarithmic specification, the technical efficiency of the *i*th firm is defined from equation 2.1 as $TE_i = \exp(-u_i)$. Therefore, the technical inefficiency of the *i*th firm is measured by $1 - TE_i$. Also, for smaller values of u_i, $1 - TE_i = 1 - \exp(-u_i)$ which is the inefficiency, can be approximated by u_i. This implies that the equation can be reformulated as

$$y_{it} = \alpha_i + x_{it}\beta + v_{it} \,, \tag{2.2}$$

where $\alpha_i = \alpha - u_i$

Modern Approaches

The most recent extensions to the stochastic frontier production function approach that are reviewed in this part are studies by Desli et al (2003) and Huang (2004).

Desli et al's Approach

Desli et al. (2003), extended the stochastic frontier model to allow for efficiency change through firm specific intercept which evolves over time as first order auto-regressive process (AR (1)) in a panel data framework. Their model is consistent with the belief that people learn from their mistakes gradually. Thus, an inefficient firm is allowed to correct its inefficiency from the past. They specified their model as

$$y_{it} = \alpha_i + \phi y_{i,t-1} + x_{it}\beta - x_{i,t-1}\phi\beta + w_{it}\gamma + \varepsilon_{it}, \qquad (2.3)$$

where $\varepsilon_{it} = (v_{it} - \phi v_{i,t-1}) - u_{it}; \quad u_{it} \geq 0.$

w_{it} represents systematic factors that might persistently influence the firms productivity and the position of the firms production frontier over time. They defined the composed error term ε as having one component $(v_{it} - \phi v_{i,t-1})$ which follows an MA(1) process that is two sided $(-\infty, +\infty)$, whiles the other component (u_{it}) is one-sided $(0, +\infty)$.

Technical efficiency of a firm *i* at time *t* is measured by $u_{it} = y_{it}^f - y_{it}$. This is the deviation of the observed output, y_{it}, from the maximal producible output (y_{it}^f) given by

$$y_{it}^f = \alpha_i + \phi y_{i,t-1} + x_{it}\beta - x_{i,t-1}\phi\beta + w_{it}\gamma \, .$$
(2.4)

And technical efficiency (TE) is measured by

$$TE = e^{y_{it} - y_{it}^f} = e^{-u_{it}} . \tag{2.5}$$

As explained by Desli et al. (2003), the model is dynamic since lagged value of y appears as a regressor, implying that past history of inefficiency affects present output. Secondly, technical inefficiency is separated from time-invariant firm effect (α_i). Finally, they explained that if time is introduced as a regressor in the model via w_{it}, technical change can be estimated exogenously from $\partial y / \partial t$ and technical change can be separated from technical efficiency as $TE_{it} - TE_{i,t-1}$. The authors further gave detailed descriptions for the estimation of the model.

Huang's Approach

Huang (2004) proposes a flexible stochastic frontier model with random coefficients to distinguish technical inefficiency from technological differences across firms. Haung (2004) specified the model as:

$$y_i = \alpha + x_i'\beta + z_i'\gamma_i + v_i - u_i , \tag{2.6}$$

where z_i is a $k' \times 1 (k' \leq k)$ vector of variables that are a subset of x_i. The corresponding $k' \times 1$ vector of coefficients $\gamma = (\gamma_{i1} + \gamma_{i2}, ..., \gamma_{ik'})'$ for the *i*th firm is assumed to be independently, identically and normally distributed with mean vector 0 and variance-covariance matrix Ω, that is
$\gamma_i \sim N_{k'}(0, \Omega)$.

The model thus distinguishes technical inefficiency from technological differences across firms.

2.1.2 Stochastic Frontier Metaproduction Approach

Further developments of the stochastic frontier model led to the stochastic frontier metaproduction model. Hayami (1969) and Hayami and Ruttan (1970) introduced the concept of metaproduction function for the assessment of efficiency. They defined the metaproduction function as "the envelope of commonly conceived neoclassical production functions". Thus, it is a common underlying production function that is used to represent the input-output relationship of a given industry (Lau and Yotopoulos 1989). The metaproduction function concept is based on the hypothesis that all producers in different groups have potential access to the same technology. However, each producer may choose to operate on a different part of it depending on circumstances such as the natural endowments, relative prices of inputs, and the economic environment (Lau and Yotopoulos 1989). Recent extensions and modification of the stochastic frontier metaproduction function approach is found in Battese and Rao (2001), which is reviewed below.

The Stochastic Metaproduction Model by Battese and Rao (2001)

Battese and Rao (2001), showed how technical efficiency scores for firms across regions can be estimated using a stochastic frontier metaproduction function model, and used a decomposition result to present an analysis of regional productivity potential and efficiency levels.

If stochastic frontier models are defined for different regions within an industry, and for the *j*th region, there exist sample data on N_j firms that produce one output from the various inputs. The stochastic frontier model for this region is specified as

$$Y_{ij} = f(x_{ij}, \beta_j) e^{V_{ij} - U_{ij}}, i = 1, 2, \ldots, N_j \qquad (2.7)$$

It is assumed that the V_{ij}s are identically and independently distributed as $N(0,\sigma_v^2)$-random variables, independent of the U_{ij}s, which are defined by the truncation (at zero) of the $N(0,\sigma_v^2)$-distributions. Omitting the subscript *j* to simplify the model for the *j*th group gives

$$Y_i = f(x_i, \beta) e^{V_i - U_i} \equiv e^{x_i \beta + V_i - U_i} . \tag{2.8}$$

The stochastic frontier metaproduction function model for all firms in all regions of the industry is defined as

$$Y_i = f(x_i, \beta^*) e^{V_i^* - U_i^*} \equiv e^{x_i \beta^* + V_i^* - U_i^*}, i = 1, 2, \ldots, N \tag{2.9}$$

where $N = \sum_{j=1}^{R} N_j$ is the total number of sample firms in all (R) regions.

The maximum-likelihood estimates of the parameters of the above stochastic frontier metaproduction function do not necessarily result in the estimated function being an envelope of the individual regional production functions. This is because if the assumptions for the regional frontiers are satisfied, those associated with the stochastic frontier metaproduction function may not be satisfied. However, Battese and Rao (2001) discussed that it is possible to constraint the estimation of the metaproduction function (equation 2.9) such that it is an envelope of observations for efficient firms in all regions.

Battese and Rao (2001) showed that the model for the *j*th group and the stochastic frontier metaproduction function yields the following identity relationship:

$$1 = \frac{e^{x_i \beta}}{e^{x_i \beta^*}} \cdot \frac{e^{V_i}}{e^{V_i^*}} \cdot \frac{e^{-U_i}}{e^{-U_i^*}} , \tag{2.10}$$

Where the three ratios on the right-hand side of the above equation are called productivity potential ratio (PPR), the random error ratio (RER) and the technical efficiency ratio (TER), respectively

$$PPR_i \equiv \frac{e^{x_i\beta}}{e^{x_i\beta^*}} \equiv e^{-x_i(\beta^*-\beta)},\; RER_i \equiv \frac{e^{V_i}}{e^{V_i^*}} \equiv e^{V_i - V_i^*}, \text{ and } TER_i \equiv \frac{e^{-U_i}}{e^{-U_i^*}} \equiv \frac{TE_i}{TE_i^*}. \quad (2.11)$$

Battese and Rao (2001) defined the productivity potential ratio as the potential productivity increases for the given region, according to currently available technology for firms in a given region relative to the technology available in the whole industry. The technical efficiency of firm *i*, relative to its regional frontier, $TE \equiv e^{-U_i}$, is estimated by $\hat{TE} \equiv E(e^{-U_i} / E_i \equiv V_i - U_i)$, and the technical efficiency of firm *i*, relative to the metaproduction frontier is estimated as

$$\hat{TE}_i^* \equiv E(e^{-U_i^*} / E_i^* \equiv V_i^* - U_i^*).\; E_i^* \equiv E_i - x_i(\beta^* - \beta) \quad (2.12)$$

2.1.3 Stochastic Metafrontier Approach

The stochastic metafrontier model is an extension of the metaproduction function model. The technique proposed by Battese and Rao (2002) is used for the measure of technical efficiency ratios as well as technology gap ratios for firms in a group relative to the best practice in the industry.

In an analogous way as the stochastic frontier metaproduction function, the stochastic metafrontier function is expressed as in equation (2.9). However, Battese and Rao (2002) explained that the metafrontier function is an envelope of the stochastic frontiers of the different groups such that it is defined by all observations in the different groups in a way that is consistent with the specifications of a stochastic frontier model. Observations on individual firms in the different groups may be greater than the deterministic component of the stochastic frontier model, but deviations from the stochastic frontier outputs are due to inefficiency of the firms in the different groups. The stochastic frontiers for the different groups and that of the metafrontier would generally be assumed to be of the same functional form (for example Cobb-Douglas or translog), but there are no problems of aggregation as with the relationship between firm and industry functions.

It is easily identified that the identity relationship in equation (2.10) of the stochastic frontier metaproduction function also holds for the stochastic metafrontier function. However, for the stochastic metafrontier function, the three ratios on the right-hand side of equation (2.10) are called the technology gap ratio (TGR), the random error ratio (RER) and the technical efficiency ratio (TER). Thus

$$TGR_i \equiv \frac{e^{x_i\beta}}{e^{x_i\beta^*}} \equiv e^{-x_i(\beta^*-\beta)},\ RER_i \equiv \frac{e^{V_i}}{e^{V_i^*}} \equiv e^{V_i - V_i^*},\ \text{and } TER_i \equiv \frac{e^{-U_i}}{e^{-U_i^*}} \equiv \frac{TE_i}{TE_i^*}. \qquad (2.13)$$

According to Battese and Rao (2002), the technology gap ratio indicates the technology gap for the given group according to currently available technology for firms in that group, relative to the technology available in the whole industry. The technical efficiency of firm *i*, relative to its regional frontier, $TE \equiv e^{-U_i}$, is estimated by $\hat{TE} \equiv E(e^{-U_i} / E_i \equiv V_i - U_i)$, and the technical efficiency of firm *i*, relative to the metafrontier is estimated as $\hat{TE}_i^* \equiv E(e^{-U_i^*} / E_i^* \equiv V_i^* - U_i^*)$. The identity $E_i^* \equiv E_i - x_i(\beta^* - \beta)$ is satisfied.

The Metafrontier model by Battese et al (2004)

If we denote *i* = 1, 2,…, N as an index of firms in a group *j*, *t* = 1, 2,…, T to index time periods, according to Battese et al (2004), if inputs and outputs for firms in a given industry are such that stochastic frontier production function models exist for R different groups (*j*= 1, 2,…, R) within the industry, then the stochastic frontier model for the *j*th group is defined as

$$Y_{it(j)} = f(X_{it(j)}, \beta_{(j)}) e^{V_{it(j)} - U_{it(j)}} \qquad (2.14)$$

where $Y_{it(j)}$ is the performance or output of firm *i* in period *t* for the *j*th group,
$X_{it(j)}$ is the vector of inputs or functions of inputs used by the *i*th firm in the *t*th time period for the *j*th group,
$\beta_{(j)}$ is a vector of parameters associated with the *x*-variables for the stochastic frontier for the *j*th group involved,
$V_{it(j)}$s are statistical noise terms assumed to be independently and identically distributed as $N(0,\sigma^2_{v(j)})$-random variables, independent of the $U_{it(j)}$s, defined by the truncation (at zero) of the $N(\mu_{it(j)},\sigma^2_{(j)})$-distributions, where the $\mu_{it(j)}$s are defined by some appropriate inefficiency model. The model for the *j*th group is thus simplified as

$$Y_{it} = f(X_{it}, \beta_{(j)})e^{V_{it(j)}-U_{it(j)}} \equiv e^{X_{it}\beta_{(j)}+V_{it(j)}-U_{it(j)}} \qquad (2.15)$$

From the above expression, it is assumed that the exponent of the frontier production function is linear in the parameter vector, $\beta_{(j)}$ so that X_{it} is a vector of functions of the inputs for the *i*th firm in the *t*th time period (Battese et al 2004).

Battese et al (2004) define the metafrontier function as "a production function of specified functional form that does not fall below the deterministic functions for the stochastic frontier models of the groups involved". Thus, they expressed the metafrontier production function model for all firms in the industry as

$$Y^*_{it} \equiv f(X_{it}, \beta^*) = e^{X_{it}\beta^*},\ i = 1,2,...,\ N = \sum_{j=1}^{R} N_j;\ t = 1,2,...,\ T \qquad (2.16)$$

where β^* is the vector of parameters for the metafrontier function such that

$$X_{it}\beta^* \geq X_{it}\beta_{(j)} \qquad (2.17)$$

Efficiency Level and Technology Gap

From Battese et al (2004), an alternative expression for the output that is observed for the *i*th firm in the *t*th time period, which is defined by the stochastic frontier for the *j*th group in equation (2.15), is

$$Y_{it} = e^{-U_{it(j)}} \times \frac{e^{X_{it}\beta_j}}{e^{X_{it}\beta^*}} \times e^{X_{it}\beta^* + V_{it(j)}} \quad (2.18)$$

The first term on the right-hand side of equation (2.18) is the technical efficiency relative to the stochastic frontier for the *j*th group,

$$TE_{it} = \frac{Y_{it}}{e^{X_{it}\beta_{(j)} + V_{it(j)}}} = e^{-U_{it(j)}} \quad (2.19)$$

The second term on the right-hand side of equation (2.18) is the technology gap ratio for the observation for the sample firm involved,

$$TGR = \frac{e^{X_{it}\beta_{(j)}}}{e^{X_{it}\beta^*}} \quad (2.20)$$

The technology gap ratio has values between zero and one, and measures the ratio of the output for the frontier production function for the *j*th group relative to the potential output defined by the metafrontier function, given the observed inputs.

In an analogous way to equation (2.19), the technical efficiency of the *i*th firm, for the *t*th observation relative to the metafrontier $(T\hat{E}_{it})$ is the last term on the right-hand side of equation (2.18), which is the metafrontier output adjusted for the corresponding error,

$$TE_{it}^* = \frac{Y_{it}}{e^{X_{it}\beta^* + V_{it(j)}}} \quad (2.21)$$

It follows from equation (2.18)-(2.21) that, the technical efficiency relative to the metafrontier is alternatively expressed as

$$TE_{it}^{*} = TE_{it} \times TGR_{it} \tag{2.22}$$

Equation (2.22) implies that the technical efficiency relative to the metafrontier function is the product of the technical efficiency relative to the stochastic frontier for the group involved and the technology gap ratio (TGR).

Battese et al (2004) presented the estimation procedures and also proposed two methods for the identification of the best envelope $(\hat{\beta}^{*})$: The minimum sum of absolute deviations and the minimum sum of squares of deviations.

2.2 Empirical Literature

This section presents empirical literature studies on the various approaches to efficiency measurement from the previous section (section 2.1).

2.2.1 Stochastic Frontier Approach

The stochastic frontier approaches have been applied in many studies with modifications and extensions using both cross-section and panel data. Various studies by Pit and Lee (1981), Jondrow et al (1982), among others have all been related to cross-section data. Though Pit and Lee (1981) specified a panel data version of the stochastic frontier model, Schmidt and Sickles (1984) were the first to formally modify the stochastic frontier analysis to be used for panel data. Later other authors such as Battese and Coelli (1988, 1995), Haung and Liu (1994), and Battese and Broca (1997) among others came out with some extensions and modifications of the stochastic frontier model.

Haung (2004) applied his model of flexible stochastic frontier to a real data set of 123 electricity utility companies in the United States. The empirical results of his study showed that the regression coefficients could vary across firms, which indicates the adoption of heterogeneous technologies by different firms. His findings revealed further that if the possible heterogeneity is not considered, then the inefficiency of firms could be overestimated.

2.2.2 Stochastic Metaproduction Function Approach

Applications of the metaproduction function approach can be found in Kawagoe et al (1985), Lau and Yotopoulos (1989), Kudaligama and Yanagida (2000) among others. Kawagoe et al (1985) estimated a production function using intercountry agricultural cross-section data. In Lau and Yotopoulos (1989), a metaproduction function for agriculture is estimated using cross-section data. They re-estimated the Kawagoe et al's model by using transcendental logarithmic form of the production function instead of the Cobb-Douglas production function. They also gave some econometric advantages of applying the metaproduction function approach to efficiency assessment. Kudaligama and Yanagida (2000) used the frontier metaproduction function to study intercountry agricultural differences.

2.2.3 Stochastic Metafrontier Function Approach

Rao et al (2003) applied the method to investigate the regional differences in production technologies using cross-country agricultural sector data. They developed the metafrontier concept by using alternative descriptions of production technologies. In addition to the stochastic metafrontier approach, they discussed how the DEA approach could be used to estimate metafrontiers. Thus, they used both the DEA and stochastic frontier analysis to estimate metafrontiers for countries in different regions. However, the metafrontier function in their model is a production function of specified functional form that does not fall below the deterministic functions for the stochastic frontier models of the regions involved. In their model, they assumed that the data generation models are only defined for the stochastic frontier models for the units in the different regions.

Another application of the stochastic metafrontier approach is a study by Battese et al (2004). In their study, they proposed a metafrontier production function model for the assessment of comparable technical efficiencies for firms operating under different technologies. They applied the model in the analysis of panel data on garment firms in five different regions of Indonesia, with the assumption of the regional stochastic frontier production function having technical inefficiency effects with time-varying structures.

2.3 Empirical Studies on the Ghanaian Manufacturing Industry

Empirical studies on the manufacturing industry in Ghana using the stochastic frontier approach are limited. Bigsten et al (2000) and Söderbom and Teal (2001, 2003) are the studies we could find in the literature on the efficiency of the Ghanaian manufacturing. We present below these empirical studies.

Bigsten et al (2000) used stochastic production frontier models and firm-level panel data, covering the period 1992 to 1995, for the manufacturing sector in four African countries (Cameroon, Ghana, Kenya and Zimbabwe) to investigate the association between exports and firm-level efficiency. Contrary to previous studies, they found that export has a large and significant effect on efficiency. They also found that an additional year of exporting raises efficiency in the next period by 10%, even for firms who have a previous history of exporting. They also found evidence of a learning-by-exporting effect as well as self-selection of the most efficient firms into exporting and concluded that the effect of exporting on efficiency appears to be larger in this African sample than in comparable studies of other regions which are consistent with the smaller size of domestic markets.

Söderbom and Teal (2001) investigated the role of size and human capital in determining both earnings and productivity using a panel data set from Ghana's manufacturing sector. They employed Generalized Method of Moments (GMM) estimator to control for issues of endogeneity, measurement errors and fixed firm effects. Using the empirical results, they argued that size is the most important of the factors determining earnings across firms of differing size.

They also used a production function to show the existence of constant returns to scale exhibited by the data. Allowing for measurement error, they showed the existence of the Cobb-Douglas form with constant returns to scale, thus accepting the hypothesis that technology is homothetic. Their results also showed a weak effect of human capital in explaining either distribution of earnings and productivity across firms of differing size.

Söderbom and Teal (2003) used a stochastic frontier model to investigate the performance of firms in Ghana’s manufacturing sector. They investigated issues of technology choice, and the importance of technical and allocative efficiency using a seven-year panel data. They used a simple functional form, the Cobb-Douglas production function, to represent the production technology thus assuming homothetic technology. They reported that technical inefficiency is not lower in firms with foreign ownership and its dispersion across firms is similar to that found in other economies, hence there is no evidence that firms in Africa are inefficient. They argued that measures of human capital are not quantitatively very important in determining productivity. They show that the diversity of factor choices is not due to a non-homothetic technology and that observable skills are not quantitatively important as determinants of productivity.

2.4 Thesis contribution

This study makes a contribution in diverse ways. The study adds to the literature on efficiency of manufacturing firms in Ghana, employing the metafrontier model, which acknowledges differences in technology. When it is evident that there are differences in technology with two groups, it is normally inadequate to use only stochastic frontier analysis. The use of the metafrontier, which acknowledges this difference, gives better assessments of the efficiency scores. The stochastic frontier is only applicable if the likelihood ratio test indicates no differences in technology. However, for this case the likelihood ratio test reveals technological differences between the firms with foreign presence and those without foreign presence. Hence, the application of the metafrontier technique gives better comparisons hence better results.

In addition, the study would serve as a guide to policy makers. It is a well-established fact that capital and labor are very important in the productivity of firms. Consequently, firms in developing countries usually receive foreign direct investment (FDI) flows from developed countries in the form of physical capital and technocrats. Our thesis report seeks to make a distinction between physical capital and foreign human capital and investigates the importance of foreign human capital by comparing the efficiency of manufacturing firms with foreign ownership or foreign presence to that of the local firms. The results of this study would be very useful to policy makers in the sense that if the results indicate that foreign technocrats are very necessary for high productive efficiency of manufacturing firms, then, as a guide, the policy makers would make efforts to encourage the inflow of foreign human capital which would in the long run help to improve the economy as a whole. On the other hand, if the results prove otherwise, policy makers could also help by improving on the physical capital flow to local firms.

3.0 MANUFACTURING FIRMS IN GHANA

This chapter examines the composition and the performance of the Ghanaian manufacturing sector with emphasis on the sector's contribution to real Gross Domestic Product (GDP), production or output and export, and employment as well as firms with foreign presence.

3.1 Composition of the Manufacturing Sector of Ghana

The Manufacturing sector of Ghana is one of the most important sectors of the economy besides the Agriculture and Service sectors. The manufacturing sector comprises a total of 25,931 firms[4]. The firms are broadly classified into three main categories, which are small, medium and large scales. According to the Statistical Services of Ghana's definition, a firm is a small scale where its work force is less than 30 employees, while a medium scale refers to a firm with work force between 31 and 100. And a large-scale firm has labor force of more than one hundred (100) employees. The firms are in manufacturing activities requiring low technology. Thus the manufacturing sector, which is the dominant sub-sector in the industrial sector, is made up of food and beverages; textile, garment and leather; wood; chemical; petroleum; non-metallic mineral products, iron and steel and non-ferrous metal products; and fabricated metals and machinery. However, petroleum, food, and textiles dominate the sector; together they account for 47% of total manufacturing output (Baah-Nuakoh 2003). It is interesting to note that, of the numerous firms, most of these manufacturing firms are located in Accra, Tema, Takoradi, Kumasi and Cape Coast. Notable among them are Volta Aluminum Company (VALCO), Tema Steel Works, Ghana Cement, Nestle Ghana Limited, Accra Breweries, Unilever Ghana, Pioneer Food Cannery, Tema Oil Refinery, Ghana Textile Printing Company and Accra Brewery among others. These firms can be conveniently categorized into four main divisions as follows:

[4] Ghana Statistical Service, Provisional figure from the 2003 National Industrial Census phase-1.

The Beverage and Food Industry: The beverage industry consists of firms producing alcoholic and non-alcoholic beverages. The industry comprises four sub-industries, which are classified as soft drinks and carbonated water, wine, distilleries, malt liquor and beer. Firms producing canned food such as canned tuna, cooking oil, tomato paste, beverages, cereal products and other edible products constitute the food industry.

The Textile, Garment & Leather: This division embraces the firms producing cloth, leather products and wearing apparel.

The Non-ferrous metal basic industries: This industry embraces firms in the production of iron rods, nails and other non-ferrous metal products.

Wood Products: It refers to the firms that are engaged in saw milling, wood processing and related products.

Table 1 shows the percentage distribution of the sectorial composition of the Ghanaian manufacturing.

Table 1: Distribution of the Ghanaian Manufacturing in 2002

Sector	Percentage
Non-ferrous metal basic industries	10%
Chemical products other than petroleum	7%
Petroleum	19%
Sawmill & Wood	7%
Textile, Wearing Apparel & Leather	14%
Tobacco	8%
Beverages	8%
Food	16%
Others	11%

Source: Ghana Statistical Services.

3.2 Performance of the Manufacturing Sector

The Institute of Statistical, Social and Economic Research (ISSER) report (2002) indicates that total output of the industrial sector has been unstable over the past decade. After rising from 3.7% in 1991 to 6.4% in 1997, it fell to 2.9% in 2001 and then rose to 4.7% in 2002. Thus, the industrial output of which the manufacturing output dominates continues to lag behind agriculture and services in terms of its contribution to GDP. For instance, it accounted for about 25% of real GDP in 2002 compared to 35.8% for agriculture and 29.9% for the service sectors. However, the importance of the manufacturing sector to the economy of Ghana cannot be overemphasized. It has remained the dominant sub-sector within the industrial sector, contributing about 60% of the total value of industrial production over the years. The sector's contribution stood at nearly 15% of real Gross Domestic Product (GDP) in the 1970s but declined to 8.9% in 1996 before rising slightly to 9% in 2002 (Baah-Nuakoh 2003). This is consistent with ISSER (2000) report on the State of the Ghanaian Economy that indicates that the sector's share in the real GDP has remained on average at 8.5% between 1990 and 1999.

The manufacturing sector maintained its position as the leading contributor to the real GDP among others within the industrial sector. Its share to real GDP ranged between 7.2% and 10% for the period 1981 to 1999. Also, in 2002, the manufacturing sector grew by 4.8%, which was about 1.1% above that of 2001. Though the petroleum, food and textile industries together grew by 3% points to 50% of manufacturing GDP in 2003, ISSER (2003) explains that with the sector's share of total industrial output hovering around 37% for a decade, manufacturing has been under-performing.

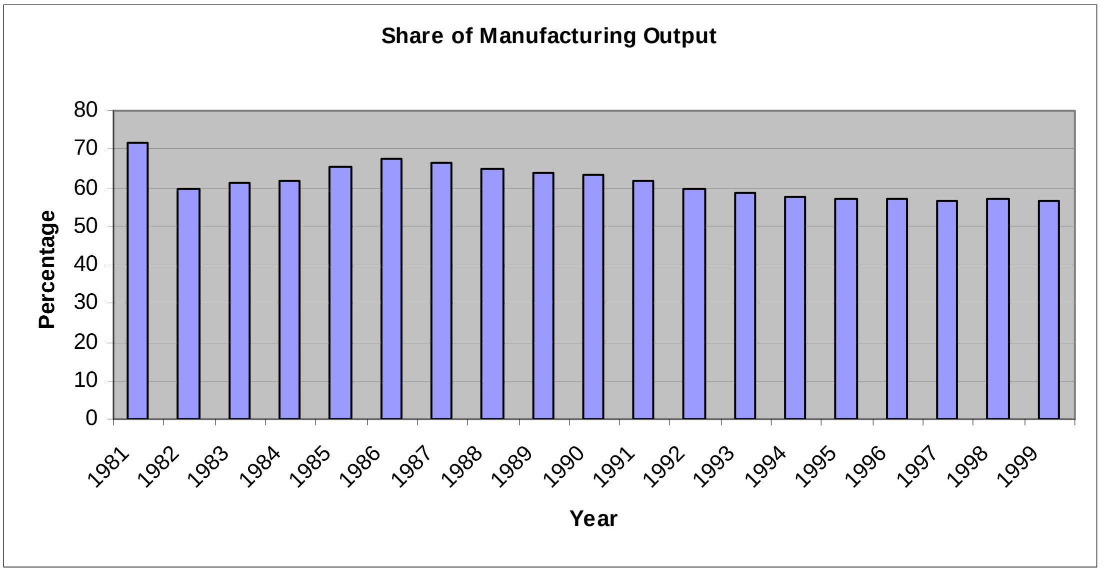
Manufacturing production for the ERP period 1985 to 1998 for 15 sub sectors with 1977 as the base year reveals that saw milling, cement and non-metallic mineral products; beverages and petroleum refinery are the more dynamic sub sectors within the manufacturing sector. Baah-Nuakoh (2003) argued that the industries that have not performed well are those that face foreign competition and depend on imported inputs. They included textile, wearing apparel and electrical equipment. The Statistical Services estimated capacity utilization for medium and large scale manufacturing establishments. It found out that capacity utilization in manufacturing increased from a low 18% in 1984 to 45.7% in 1993. Specifically, non-metallic minerals and wood processing recorded capacity utilization of 72.8% and 65% respectively.

For the year 2003, there was increased production of textile and garments relative to total manufacturing production but the rate was less than expected. This was attributed to the unfair competition from dumping, and from pirated and smuggled products. The local textile production remains below 1977 levels and in 2003, the production index was just about 60 (ISSER 2003). Furthermore, while some industries within the manufacturing sector have experienced growth, others including non-ferrous products; chemicals have not only lost their share in total manufacturing output but have been experiencing declining growth. A notable example among them is sawmill and wood industry. It has registered some decline in production and export revenue due to depletion of forest reserves on which the industry depends for its raw material. Hence, its index of production has declined from 140 in 2000 to 125.5 in 2003 (ISSER 2003).

Closely linked to the GDP is the sector’s performance in terms of output. It can be seen from Figure 1 that the sector continues to reign as the dominant sector contributing over half of the total output. The manufacturing sector however performed relatively poor from 1989 to 1999. Baah-Nuakoh (2003) argued that the declined growth rate of the manufacturing sector is an obvious manifestation of the problems, which accompanied the rapid liberalization of trade and exchange rate coupled with financial reforms and its attendant high interest rate that compelled many import dependent industries to battle with high cost of production.

Figure 1 illustrates the share of manufacturing output for the period under discussion.

Figure 1: Share of Manufacturing Output (1981-1999)



Source: Baah-Nuakoh (2003) Compiled from National Account Data; *Quarterly Digest of Statistics*, Various Issues. The computation adopted 1977 as the base year.

It can be argued that the growth rate and relative contribution of Ghana's manufacturing sector to GDP compares favorably with those of a number of African countries. However the level is still far below that of the fast-growing countries of the Association of South-East Asian Nations (ASEAN) where manufacturing contributes more than two thirds of the total GDP and has expanded at an annual rate of 19 % since 1980 (ADB figures cited in ASEAN 2002).

Also, production for all manufacturing industries showed some upward trend since 1998 as reported by Baah-Nuakoh (2003). He attributed the turn around in manufacturing production to stable macroeconomic environment and further argued that the low base from which there has been some improvement provides ample evidence of the major problem confronting the manufacturing sector in Ghana.

Growth in manufacturing has been very uneven, with four major sub-sectors recording negative growth since 1998. They are sawmill and wood products, tobacco products, cutlery and non-ferrous products, and chemical products, according to a joint study published in 2002 by the United Nations Development Programme (UNDP), United Nations Industrial Development Organization (UNIDO) and Ministry of Trade and Industry, Ghana. On the other hand, growth has been strongest in non-ferrous base metals, cement, other non-metallic products; petroleum and refining (Baah-Nuakoh 2003).

The sector's contribution to employment is documented in ISSER reports. The sector registered some improvement in employment. According to ISSER (2001), the rise in employment in industrial sector in general over the years has significantly originated from the growth of some divested state-manufacturing firms. Notable among them is Tema Steel Company, Ghana Agro-Food Company, Coca-Cola Bottling Company of Ghana, Ghana Rubber Estate limited and West Africa Mills, with employment of 2,822 as at the end of 1998. Furthermore, ISSER (2000) indicates that out of the employment opportunities generated by Ghana Investment Promotion Center for 61,361 Ghanaians and 3,855 non-Ghanaians, the manufacturing sector accounted for 21,200 representing 32.5% and comprising 20,111 Ghanaians and 1,089 non-Ghanaians.

With regards to exports, it is estimated that 70% of the manufacturing sector's exports comprise wood products, cocoa butter, cocoa paste, tuna products and cotton. Again, ISSER (2002) reveals that primary food and beverages for industry and processed foods and beverages account for over 90% of Ghana's manufactured exports. The interesting trend as regards the manufactured exports is illustrated in Table 2.

Table 2: Trend in Manufactured Exports, 1997 –2002 (US $million)

	1997	1998	1999	2000	2001	2002
Processed & Semi-Processed	253.7	317.5	313.31	321.12	362.73	407.2
Of which: wood	71	84.6	85.5	108.3	111.4	107.6
Aluminium	5.8	12.2	14.8	12.3	12.52	32.8
Foods and Beverages	51.82	80.03	68.3	71.7	56.35	85.6

Source: Bank of Ghana, Ghana Export Promotion Council.

Despite the increase in manufactured exports, the share of manufactured exports in Ghana's total merchandise exports remains relatively small compared to that of several other African countries. Besides, Ghana's exports of processed and semi processed goods are highly concentrated in the wood sector, in contrast to what pertains in sub-Saharan countries such as Kenya and Zimbabwe (Söderbom 2002).

3.3 Constraints of Manufacturing Firms in Ghana

A crucial ingredient for manufacturing growth is the availability of credit. However, the manufacturing firms or the sector seems to be getting a dwindling share of total credit to the industrial sector. For instance, its portion fell from 60.94% in 2000 to 59.63% in 2001 and to 56.71% in 2002 (ISSER 2002). Also, the cost of credit remained high with average lending rate for the manufacturing sector falling marginally from 47% in 2000 to 46% in November 2001. Consequently, this made it difficult for most manufacturing firms to access credit from banks. The high cost of credit also implied that Small and Medium scale Enterprises (SMEs) could not access credit from the financial market making their operations difficult. This argument is consistent with studies by Osei et al (1993), Webster and Steel (1991), Anheir and Seibel (1987) and Thomi and Yankson (1985). These studies were concentrated on small and medium scale enterprises and were conducted to find out the major constraints to the operations and expansion of Ghanaian manufacturing firms.

They found a high proportion of firms citing lack of access to credit as a major constraint.

Similarly, ISSER (2002) identifies lack of a continuous and reliable supply of energy or power and water as major hindrance to manufacturing productivity in Ghana. Though Ghana generated an average of about 7 billion kilowatts of electricity annually since 1995 with about 14% imported, electricity supply to private manufacturing customers remained unstable while a substantial share is consumed by VALCO and mining companies. Also, the annual growth of national demand for power is estimated at 10-14% and the inability to fulfill this demand has been a major constraint on the manufacturing firms productivity and growth.

Baah-Nuakoh (2003) discusses some of the constraints of the manufacturing firms, which include the production techniques and macroeconomic environment. According to him, the problem of the sector can be defined as the low level of sophistication of production techniques and output. Unlike South Africa, for example, where about 60% of manufacturing output comprises high technology, high value-added products, Ghana's manufacturing sector produces largely low technology products. These include beverages, textiles, wood products, chemical and petroleum products, cement, iron and steel; ferrous and non-ferrous metal products as well as electrical equipment and appliances.

It has been argued that the poor performance of the manufacturing sector could be attributed to a large extent to the unfavorable macroeconomic situation, for example high inflationary rates. Among the indicators were that most of the manufacturing firms borrowed at a higher cost and coupled with the rapid depreciation of the local currency vis-à-vis other currencies, the firms especially the import dependent ones end up producing at a higher cost or cut back production (ISSER 2000). It follows that the unfavorable macroeconomic environment significantly cripples the domestic manufacturing firms. Baah-Nuakoh (2003) also found that the problems of the manufacturing sector are further compounded by lack of effective linkages between manufacturing and other sectors, especially agriculture.

Finally, ISSER (2000) report identifies lack of market information as a problem or constraint that has made it difficult for Ghanaian manufacturing firms to penetrate the external market, which adversely affects their output and export performance. It is therefore expected that effort will be made to minimize these problems or constraints and improve the macroeconomic and financial management to make credit affordable to manufacturers so as to enhance their productivities.

3.4 Manufacturing Firms with Foreign Presence

Data at the Ghana Investment Promotion Center indicates that for the period September 1994 to December 2000, a total of 300 manufacturing firms or projects in Ghana were on record as firms with foreign presence. This represents 27.68% of manufacturing firms and in terms of value of investment; together they accounted for total investment cost of US$319.82million, which is 19.88%. Similarly, for the period January 2001 to June 2004, Manufacturing maintains the lead as a sector attracting the highest number of projects with 153 firms. Thus, the total-manufacturing firms with foreign ownership and /or foreign presence increased by 153 as at June 2004 with estimated investment cost of US$62.27million. Again, the Ghana Investment Promotion Center registered between 26% to 30% new manufacturing firms in 2001 to 2003. In terms of value of investment, these firms' investment costs for 2001 to 2003 ranges from about US$ 10million to US$22million. As mentioned earlier, most of these firms are in processing and semi- processing of food and beverages, wood products, chemicals and building materials among others. Table 3 shows the pattern of manufacturing firms with foreign presence and their investment costs for the period September 1994 to June 2004.

Table 3: Ghanaian Manufacturing Firms with Foreign Ownership and Foreign Presence (September 1994 –June 2004)

Period/Year	Number of Firms	Percentage	Investment Costs (US$M)	Percentage
Sept. 1994-Dec 2004	300	27.68	319.82	19.88
2001	45	26.32	9.58	9.84
2002	42	30.43	16.24	24.93
2003	42	27.63	21.94	18.54
January–June 2004	24	28.57	14.51	28.46

Source: Ghana Investment Promotion Center, 2004.

In the case of employment, a total of 20,680 Ghanaians and 1,122 Non-Ghanaian or expatriates were to be employed by the 300 manufacturing firms for the period September 1994 to December 2000 and the employment level of the firms stood at 6,907 Ghanaians and 490 Non-Ghanaians. It can be seen from Table 4 that while about 94.85% of the employees of all the firms are Ghanaians in 2000, 5% are expatriates. With the increase in the number of the manufacturing firms by 153 as at June 2004, the expatriates' employees also increased to 6%.

Table 4: Firms with Foreign Ownership/Presence and their Employment Levels (Expected Employment Creation by Projects)

Period/Year	Ghanaians	Non-Ghanaians
September 1994-December 2000	20 680	1 122
2001	1 512	106
2002	1 668	152
2003	1 973	132
January-June 2004	1 264	100

Source: Ghana Investment Promotion Center, Second Quarter 2004.

4.0 METHODOLOGY

In this section, we employ the stochastic metafrontier production function technique to assess the technical efficiency of manufacturing firms in Ghana.

The stochastic metafrontier method is appropriate for our study because the metafrontier function concept is best to use for groups that have differences in technology. Most stochastic frontier methods put the data for the different groups together to estimate the efficiency scores. However, the fact that there are differences in technology, which is evident in the Ghanaian situation, could lead to an estimation bias.

The following procedure is used in the assessment of the efficiency of the Ghanaian manufacturing firms.

- Specify production functions for the two groups (i.e. firms with foreign presence and local firms)
- Estimate Stochastic Frontier for each group
- Perform Likelihood Ratio (LR) tests
- Construct the metafrontier if test indicates significant difference
- Estimate Technology Gap Ratio (TGR) and Technical Efficiency Ratio (TER)
- Estimate a Tobit model to verify the determinants of technical efficiency in each group.

4.1 Specification of the Production Functions

Strictly following Battese et al (2004), the stochastic frontier production function model for the groups in the manufacturing industry is presented. We specify a translog stochastic frontier production function for the firms with foreign presence and local firms in the manufacturing industry of Ghana as follows:

$$y_{git} = \alpha_g + \beta_{1g} k_{git} + \beta_{2g} l_{git} + \beta_{3g} l_{git}^2 + \beta_{4g} k_{git}^2 + \beta_{5g} l_{git} k_{git} + v_{git} - u_{git} \quad (4.1)$$

where all the variables are in natural logarithms; $y = Y_F, Y_W$ is valued added, defined as output less cost of raw materials and indirect inputs; $g = F, W$; F denotes firms with foreign presence and W denotes local firms or firms without foreign presence; $k = K_F, K_W$ denotes physical capital for firms with foreign presence and firms without foreign presence; $l = L_F, L_W$ denotes labor for firms with foreign presence and firms without foreign presence, respectively; i denotes firms and t denotes time periods; $v = V_F, V_W$ is a two-sided error term assumed to be identically and independently distributed; $u = U_F, U_W$ is a non-negative technical inefficiency component of the error term; α and β are parameters to be estimated.

4.2 Estimation of Stochastic Frontier for each Group

The stochastic frontiers was estimated from equation (4.1), using the Frontier 4.1 program by Coelli (1996) for the two groups, F and W (firms with foreign presence and firms without foreign presence).

4.3 Likelihood Ratio Tests

The likelihood ratio test is an important aspect of the process. It helps us to determine whether the metafrontier is really necessary for estimating the efficiency levels of the firms. If the two groups (firms with foreign presence and firms without foreign presence) share the same technology, then the stochastic frontier production model is enough to estimate the efficiency of the firms. A likelihood ratio (LR) test with the null hypothesis that the stochastic frontier models for the two groups are the same was calculated. This was calculated after estimating the stochastic frontier by pooling the data from all the two groups of firms.

The LR Statistic is defined by $\lambda = -2\{\ln[L(H_0)/L(H_1)]\} = -2\{\ln[L(H_0)] - \ln[L(H_1)]\}$. Where $\ln[L(H_0)]$ is the value of the log likelihood functions for the stochastic frontier estimated by pooling the data for all the two groups, and $\ln[L(H_1)]$ is the sum of the values of the log-likelihood functions for the two stochastic production functions (F+W) estimated separately.

4.4 Construction of the Metafrontier

At this stage, we obtained estimates of $\hat{\beta}^*$ for the β^* parameters of the metafrontier function. This is done in such a way that the estimated function best envelops the deterministic components of the estimated stochastic frontiers for the different groups. Battese et al (2004) proposed two methods to identify the best envelope: the minimum sum of absolute deviations and the minimum sum of squares of deviations. We employed the minimum sum of absolute deviations in the construction of the metafrontier. The use of this method involves solving the following linear programming (LP) problem:

Min $L^* \equiv \bar{X}_{it}\beta^*$ (4.2)

s.t. $X_{it}\beta^* \geq X_{it}\hat{\beta}_{(j)}$ (4.3)

where $\bar{X}$ is the row vector of means of the elements of the X_{it} vectors for all observations in the data set, $\hat{\beta}_{(j)}$s are the estimated coefficients of the group stochastic frontiers and β^* are parameters of the metafrontier function.

4.5 Estimation of Technology Gap Ratio (TGR) and Technical Efficiency Ratio (TE)

The technical efficiency relative to the stochastic frontier for each group is estimated as:

$$TE_{git} = \frac{y_{it}}{e^{\alpha_g + \beta_{1g}k_{git} + \beta_{2g}l_{git} + \beta_{3g}l_{git}^2 + \beta_{4g}k_{git}^2 + \beta_{5g}l_{git}k_{git} + v_{git}}} = e^{-u_{git}} \quad (4.4)$$

The technology gap ratio is also estimated as

$$TGR_{it} = \frac{e^{\beta_{1g}k_{git} + \beta_{2g}l_{git} + \beta_{3g}l_{git}^2 + \beta_{4g}k_{git}^2 + \beta_{5g}l_{git}k_{git}}}{e^{\beta_{1g}^*k_{git} + \beta_{2g}^*l_{git} + \beta_{3g}^*l_{git}^2 + \beta_{4g}^*k_{git}^2 + \beta_{5g}^*l_{git}k_{git}}} \quad (4.5)$$

The technical efficiency of the i th firm for the observation for time t relative to the metafrontier $(T\hat{E}_{it})$ is estimated as

$$TE_{it}^* = \frac{y_{it}}{e^{\alpha + \beta_{1g}^*k_{git} + \beta_{2g}^*l_{git} + \beta_{3g}^*l_{git}^2 + \beta_{4g}^*k_{git}^2 + \beta_{5g}^*l_{git}k_{git}}} \quad (4.6)$$

Thus the technical efficiency relative to the metafrontier is alternatively defined from equations (4.4) –(4.6) as the product of the technical efficiency relative to the stochastic frontier for each group involved and the technology gap ratio (TGR) defined below

$$TE_{it}^* = TE_{git} \times TGR_{git} \quad (4.7)$$

4.6 Estimation of Tobit Model

The Tobit model was estimated to verify the determinants of technical efficiency in each of the two groups. This is a limited dependent variable model, censored or truncated model where restrictions are put on values taken by the regressand. Since technical efficiency scores have upper and lower bounds of one and zero, the Tobit model is the most desirable estimation technique. Thus:

$$TE_{git} = \exp(-u_{git}) = h(\text{firm characteristics}) \tag{4.8}$$

4.7 Data Sources and Types

The data on manufacturing firms in Ghana is obtained from the Center for the Study of African Economies (CSAE), Oxford. The data was collected by the CSAE as part of the Regional Project on Enterprise Development (RPED), Ghana Manufacturing Enterprise Survey (GMES) Waves I-V. A team from the CSAE, University of Ghana, Legon and the Ghana Statistical Office (GSO), Accra collected this data. The data is a comprehensive panel data set on a sample of 200 firms within the Ghanaian Manufacturing sector. This sample of firms, which were first surveyed in 1992, was drawn on a random basis from firms contained in the 1987 Census of Manufacturing Activities. The firms constitute a panel, which was a broad representative of the size distribution of firms across the major sectors of the industry under discussion. These sectors include food processing, textile and garments, wood products and furniture, metal products and machinery.[5]

The data contains information on annual firm level data for the years 1991 to 1997, and information on the workers for the period 1992 to 1998 for each of the firms. The data set was collected from four major localities of Ghana. These localities are the Greater Accra, Kumasi, Takoradi and Cape Coast.

[5] CSAE (2002), RPED; Ghana Manufacturing Enterprise Survey (GMES) Waves I-V.

Our motivation for the choice of this data set is that, to the best of our knowledge, it is the only existing comprehensive firm level data set available in Ghana.

Description of some Variables from the Data Set[6]

The primary data set collected by CSAE has information on the following characteristics:

- **Capital Stock:** Information on the value of the capital stock of plant and machinery were valued using the replacement value and then the sales value. Information is also available for the sales value of land and buildings.

- **Human Capital Stock:** The human capital stock available to each firm is measured by merging the worker with the firm level information. Data collected at the worker level are earnings, education, age and tenure (length in current job). The human capital stock thus comprises the age of the workforce, their education in years and the tenure of the workers.

- **Output and Raw Materials:** The data on output and raw materials are from two sources for firm specific price indices. Waves IV and V of the data has information on prices of output and material inputs of the most important goods that the firm produce, for the years 1994 to 1997. For prices covering the period 1991 to 1994, the CSAE obtained the information from the World Bank data set collected as part of a supplementary survey of the RPED project.

- **Firm Size:** The firms are grouped into various categories according to the size of the firm. The size is measured by the number of employees in each firm as follows:

[6] All figures are measured in annual terms.

- Micro Firms – Firms with between 1-5 employees inclusive
- Small Firms – 6-29 employees inclusive
- Medium Firms – 30-99 employees inclusive
- Large Firms – 100 or more employees.

- **Profit:** Firm's gross profit = Output - Raw Materials - Total Indirect Costs - Wages
- **Total Indirect Costs:** includes rent, utilities and other overheads
- **Wages:** Total firm wage bill including allowances
- **Profit Rate:** Return on Capital employed (= Profits/Capital)
- **Local Firms:** Firms with only Ghanaian ownership and employees including state-owned firms
- **Firms With Foreign Presence:** Any firm with some degree of foreign ownership and presence.

4.8 Statistical Software used

The following statistical software were used for the Data Analysis:

- Frontier Program 4.1 to estimate the stochastic frontier production functions
- Microsoft Excel for some descriptive analysis
- Stata version 8.0 to estimate the Tobit model
- Mathematica 5.0 to calculate the metafronier parameters from the linear programming problem.

5.0 DATA ANALYSIS

In this chapter, we present the results and analysis of the data used for this study.

5.1 Descriptive Statistics

The summary statistics presented in Table 5 indicate some differences in the means and standard deviations between the two groups of firms with regards to value added, capital, labor, gross profit and profit rate. The standard deviations for all the variables are higher than the means indicating wide spread around the mean of the variables. The mean values are higher for the firms with foreign presence than the local firms. The local firms, on the average, made negative returns on capital employed whilst that of firms with foreign presence made positive returns.

Furthermore, the summary statistics for age, tenure and education between the two groups of firms, on the average, show no considerable differences. The standard deviations for all the three variables are lower than the means indicating no significant variations. Generally, except age, tenure and education, the standard deviations are higher than the means for all the variables in all the two groups of firms. On the average, workers in both groups of firms are adults, aged about 34, who have worked in the firms for about 8 years. Also, entrepreneurs in both group of firms received, on the average, about 10 years of formal education. In general, the profit rate, measured by the firm's profits as a proportion of the capital stock, for all the firms in the Ghanaian manufacturing industry is negative.

Table 5: Summary Statistics

Variable	Firms with Foreign Presence	Local Firms	All Firms
Value Added			
Mean	1543518	153822.8	382824.4
St. Deviation	2781638	414377.9	1292347
Capital			
Mean	2783472	262671.8	678063.3
St. Deviation	6548692	947993.5	2934734
Labor			
Mean	123.343	28.115	43.807
St. Deviation	149.876	40.038	79.046
Age			
Mean	33.657	34.003	33.945
St. Deviation	9.920	10.042	10.011
Tenure			
Mean	8.452	8.417	8.422
St. Deviation	7.305	7.940	7.830
Education			
Mean	10.071	9.570	9.655
St. Deviation	3.122	3.164	3.159
Gross Profit			
Mean	765984.1	69585.3	184341.8
St. Deviation	2940769	368891.8	1260654
Profit Rate (ROC)			
Mean	4.515	-9.436	-7.137
St. Deviation	48.775	72.807	69.569
Number of Firms	31	156	187
Number of Observations	73	370	443

Source: Empirical results on Ghana's Manufacturing Industry Survey (1991-1997). Value Added, Capital and Gross Profit are measured in US dollars at the purchasing power parity[7]

[7] Age = age of the worker

Tenure = number of years worked in current firm

Education = formal years of education of entrepreneurs

5.2 Estimation of Stochastic Frontiers

The stochastic frontier estimates from Table 6 show that manufacturing firms in Ghana have low technical efficiency scores with a mean efficiency of about 18.7% and 15.1% for both local firms and firms with foreign presence. The constant of the regression, which is an index for the level of technology, is significant and higher for firms with foreign presence. Furthermore, capital is the only significant input for the local firms, whilst all inputs, except the square of labor, are significant for the firms with foreign presence. Although these inputs are significant for the firms with foreign presence, the coefficients for capital and the interaction between capital and labor are negative indicating that these firms have excess capital.

Table 6: Stochastic Frontier Estimates for the Groups

Explanatory Variable	Firms with Foreign Presence	Local Firms
Capital	-0.984	0.487
	(0.520)*	(0.187)***
Labor	2.885	-0.168
	(0.941)***	(0.281)
$Capital^2$	0.077	-0.019
	(0.036)**	(0.013)
$Labour^2$	0.097	0.089
	(0.110)	(0.070)
Capital*Labor	-0.206	0.045
	(0.106)*	(0.048)
Constant	11.966	8.103
	(2.392)***	(2.047)***
Mean Efficiency	0.187	0.151
Minimum	0.042	0.013
Maximum	0.529	0.665
St. Deviation	0.115	0.104
Log Likelihood	-98.270	-528.369
Number of Firms	31	156

Source: Empirical Results on Ghana's Manufacturing Industry Survey (1991-1997). Figures in parenthesis are the standard errors. ***, **, and * means significant at 1%, 5%, and 10%, respectively.

5.3 Likelihood Ratio Test

As indicated in the methodology, we compute the likelihood ratio (LR) Statistic (i.e. $\lambda = -2\left\{\ln\left[L(H_0)\right] - \ln\left[L(H_1)\right]\right\}$) to determine whether the data for the two groups (firms with foreign presence and local firms) could be pooled. The values of interest computed from the stochastic production functions are:

- $\ln[L(H_o)] = \text{-}636.7035$
- $\ln[L(H_1)] = -626.639085$
- $\lambda = 20.12883$

With 5 degrees of freedom, the chi-squared distribution from the table at 99% confidence level is 15.0863. Our estimated value of 20.12883 is outside this range. Consequently, we fail to accept the null hypothesis that the two groups of firms use similar technology in production. Thus, the data for the two groups cannot pooled. There is, therefore, a need to use the metafrontier estimation technique to estimate a common technical efficiency scores for the two groups.

5.4 Estimates of Metafrontier Technical Efficiencies and Technology Gap Ratios (TGR)

In this section, we analyze the results of the metafrontier estimates as well as the TGR estimates.

Table 7: Summary Statistics for Group Technical Efficiencies, Technology Gap Ratios and Metafrontier Technical Efficiencies

Group/Statistic	Mean	St. Deviation	Minimum	Maximum
Firms with Foreign Presence				
Group TE	0.187	0.115	0.042	0.529
Tech. Gap Ratio (TGR)	0.446	0.184	0.087	1.000
Metafrontier TE*	0.086	0.067	0.004	0.345
Local Firms				
Group TE	0.151	0.104	0.013	0.665
Tech. Gap Ratio (TGR)	0.741	0.186	0.248	1.000
Metafrontier TE*	0.109	0.076	0.012	0.439

Source: Empirical results on Ghana's Manufacturing Industry Survey (1991-1997).

The mean values for the metafrontier technical efficiencies (MTE) and the TGRs are given in Table 7. From the results, local firms are more efficient than firms with foreign presence. The local firms in the industry achieved higher mean technical efficiencies relative to the metafrontier. However, the mean technical efficiencies relative to the metafrontier are very low for both groups. The mean values for the TGRs imply that local firms produce, on the average, about 74.1% of the potential output given the technology available to the whole manufacturing industry used for this study. Conversely, firms with foreign presence produce, on the average, only about 44.6% of the potential output given the technology available to the whole industry. Despite the fact that firms with foreign presence achieved higher mean technical efficiency relative to their group stochastic frontier, they are far from the potential outputs that are defined by the metafrontier function. Both groups of firms had the maximum value for the TGR of one, indicating that in all the two groups of firms, the group stochastic frontiers were tangent to the metafrontier.

5.5 Firm Size and Technology Gap Ratios

The analysis of Table 7 indicated that the stochastic frontiers for the two groups were tangent to the metafrontier. In order to determine the category of the firm/firms that are tangent to the metafrontier, as well as the productivity potentials of the different categories of firms, we present summary statistics for the firm categories and their TGRs in Table 8.

The summary statistics of Table 8 show that medium and large firms with foreign presence, and local micro and medium firms were tangent to the metafrontier (i.e. all have maximum values equal to one). The mean TGRs show that, on the average, local firms of all categories performed better than firms with foreign presence. Furthermore, all firms with foreign presence of all categories produced, on the average, less than 60% of the potential output, with the large firms in this group having the highest TGR of 58.7%. Moreover, micro and small firms with foreign presence are far from the potential output, producing less than 30% of the potential output. On the average, local micro firms are the closest to the metafrontier, producing 82.5% of the potential output. With regards to the pooled data, micro and small firms, on the average, performed better than medium and large firms. It is interesting to note that, on the average, the lowest TGR for the local firms (i.e. medium firms, 61.1%) is higher than the highest TGR for the firms with foreign presence (i.e. large firms, 58.7%).

Table 8: Firm Size and TGR

Firm Size	*Firms with Foreign Presence*	*Local Firms*	*Pooled Data*
Micro			
Mean	0.254	0.825	0.759
St. Deviation	0.178	0.168	0.249
Minimum	0.087	0.269	0.087
Maximum	0.487	1.000	1.000
Number of Firms	3	20	21
Number of Observations	6	46	52
Small			
Mean	0.292	0.752	0.723
St. Deviation	0.079	0.180	0.208
Minimum	0.174	0.248	0.174
Maximum	0.467	0.957	0.957
Number of Firms	7	79	85
Number of Observations	16	234	250
Medium			
Mean	0.450	0.677	0.611
St. Deviation	0.131	0.198	0.208
Minimum	0.331	0.373	0.331
Maximum	1.000	1.000	1.000
Number of Firms	9	28	37
Number of Observations	26	63	89
Large			
Mean	0.587	0.644	0.616
St. Deviation	0.167	0.164	0.166
Minimum	0.452	0.307	0.307
Maximum	1.000	0.940	1.000
Number of Firms	10	10	20
Number of Observations	25	27	52

Source: Empirical results on Ghana's Manufacturing Industry Survey (1991-1997).[8]

[8] The sizes of the firms are classified according to the number of employees in each firm
Micro = firms with between 1-5 employees inclusive
Small = firms with between 6-29 employees inclusive
Medium = firms with between 30-99 employees inclusive
Large = firms with 100 or more employees.

5.6 Firm Size and Efficiency

In Table 9, we present the summary statistics for the stochastic metafrontier estimates for the different categories of firms.

The standard deviations are less that the means for the different categories of firms except for micro firms with foreign presence where the standard deviation is greater than the mean. These indicate that, on the average, there are no variations in the efficiency scores for the different categories of firms. The maximum efficiency scores for all the different categories of firms are less than 45% percent and micro and small firms with foreign presence have very low maximum efficiency scores of 11.3% and 13.4%, respectively. These results show that all the firms of all categories in the manufacturing industry in Ghana are generally less efficient. The mean efficiency scores for the firms with foreign presence show that, large firms have the highest efficiency score. On the contrary, large local firms, on the average, have the lowest efficiency scores and all the categories of firms have the same mean efficiency scores of 11%. Furthermore, although, on the average, medium firms have the lowest mean efficiency score for the pooled data, there are very little variations in the mean efficiency scores for all the firms of all the categories.

In comparing the mean efficiency scores across categories of firms, local micro, small and medium firms are, on the average, more efficient than their foreign counterparts, it is only large firms with foreign presence that are more efficient than their local counterparts. The most highly efficient category of firms is the local medium firms with a maximum efficiency score of 43.9%.

Table 9: Size and Efficiency

Firm Size	*Firms with Foreign Presence*	*Local Firms*	*Pooled Data*
Micro			
Mean	0.044	0.110	0.103
St. Deviation	0.051	0.0634	0.065
Minimum	0.004	0.022	0.004
Maximum	0.113	0.264	0.264
Number of Firms	3	20	21
Number of Observations	6	46	52
Small			
Mean	0.055	0.110	0.107
St. Deviation	0.032	0.075	0.074
Minimum	0.030	0.012	0.012
Maximum	0.134	0.385	0.385
Number of Firms	7	79	85
Number of Observations	16	234	250
Medium			
Mean	0.080	0.110	0.101
St. Deviation	0.060	0.099	0.090
Minimum	0.030	0.015	0.015
Maximum	0.269	0.439	0.439
Number of Firms	9	28	37
Number of Observations	26	63	89
Large			
Mean	0.120	0.096	0.108
St. Deviation	0.078	0.047	0.064
Minimum	0.053	0.019	0.019
Maximum	0.345	0.207	0.345
Number of Firms	10	10	20
Number of Observations	25	27	52
Number of Firms	28	128	153
Number of Observations	73	370	443

Source: Empirical results on Ghana’s Manufacturing Industry Survey (1991-1997).

5.7 Firm Size and Profitability

Tables 10 and 11 show the summary statistics for the size and profitability of the firms. The two indicators are the gross profits and profit rates[9] respectively. The negative minimum values for the gross profits for all the categories of firms for the pooled data indicate that some firms in the different categories made losses. The mean values show that, all firms of all categories made profits. Large firms made the highest profits whereas small firms made the lowest profits. The standard deviations are higher than the means implying that there are significant variations in the gross profits for all firms of all categories.

The summary statistics for the firms with foreign presence show that, on the average, all the categories of firms made positive profits. Moreover, large firms made the highest profits whereas micro firms made the smallest gross profits. The small local firms, on the average, made losses with high variations across the firms. Comparing the gross profits across categories of firms for the two groups, we observe that, on the average, firms of all the categories with foreign presence made higher profits than their local counterparts, and local small firms made losses.

[9]Gross Profits = Output-Total Cost of Raw Material Inputs-Total Indirect Costs (includes rent, utilities and other overheads)-Wages
Profit Rate = Profits/Capital

Table 10: Size and Profitability (Gross Profits)

Firm Size	*Firms with Foreign Presence*	*Local Firms*	*Pooled*
Micro			
Mean	7110.888	1319.187	1987.461
St. Deviation	37075.69	15725.41	18879.94
Minimum	-52678.75	-42215.5	-52678.75
Maximum	48608.3	66616.3	66616.3
Small			
Mean	27121.12	-1368.325	455.000
St. Deviation	94272.93	71107.33	72907.84
Minimum	-156815.8	-293918.5	-293918.5
Maximum	192423.2	485978.9	485978.9
Medium			
Mean	281602.9	171121	203396.6
St. Deviation	537183.4	405090.6	447377.5
Minimum	-574753.9	-558170.1	-574753.9
Maximum	1960385	2053688	2053688
Large			
Mean	1924978	563905.4	1218267
St. Deviation	4844600	1077947	3479751
Minimum	-12400000	-2076130	-12400000
Maximum	9383646	4682253	9383646
Number of Firms	28	128	153
Number of Observations	73	370	443

Source: Empirical results on Ghana’s Manufacturing Industry Survey (1991-1997). Gross Profit is measured in US dollars at the purchasing power parity.

The summary statistics for the profit rate is reported in Table 11. The mean values show that only large firms are making positive returns on capital employed. Small and medium firms with foreign presence, on the average, made positive returns on capital employed with small firms having very high returns on capital employed whereas the micro and large firms made negative returns. On the other hand, only large local firms made positive returns on capital employed.

Comparing the profit rates across categories of firms for the two groups show that whereas, on the average, small and medium firms with foreign presence made positive returns on capital employed, their local counterparts made negative returns on the capital employed. Moreover, whilst local large firms, on the average, made positive returns on capital employed, foreign large firms made negative returns on capital. Micro firms from all the groups made negative returns on capital employed. However, the negative returns on capital for the micro firms with foreign presence are on the average, about 800% higher than that of the local micro firms.

Table 11: Size and Profitability (Profit Rates)

Firm Size	*Firms with Foreign Presence*	*Local Firms*	*Pooled*
Micro			
Mean	-49.900	-6.183	-11.223
St. Deviation	121.222	30.647	49.682
Minimum	-296.958	-130.657	-296.957
Maximum	10.31812	89.470	89.470
Small			
Mean	26.983	-11.280	-8.832
St. Deviation	58.061	86.782	85.664
Minimum	-17.728	-1268.895	-1268.895
Maximum	185.379	145.706	185.379
Medium			
Mean	7.903	-9.321	-4.289
St. Deviation	28.553	49.979	45.3162
Minimum	-1.673	-371.100	-371.100
Maximum	142.710	47.980	142.710
Large			
Mean	-0.330	0.736	0.224
St. Deviation	2.404	1.786	2.153
Minimum	-7.802	-5.339	-7.802
Maximum	2.060	5.4464	5.446
Number of Firms	28	128	153
Number of Observations	73	370	443

Source: Empirical results on Ghana's Manufacturing Industry Survey (1991-1997). Gross Profit is measured in US dollars at the purchasing power parity.

5.8 Estimates of the Tobit Model to Verify the Determinants of Technical Efficiency

In order to verify the determinants of technical efficiency in the Ghanaian manufacturing, we estimated a panel Tobit model using the metafrontier technical efficiency estimates as the dependent variable. The results are presented in Table 12. From the results, food-producing firms, Large and Medium firms, gross profits of the firms, dummy for foreign presence, and firms located in the capital city explain technical efficiency in the Ghanaian manufacturing industry. The relationship between all these variables, but the dummy for the foreign presence, and the technical efficiency scores is positive. The negative coefficient of the dummy confirms that firms with foreign presence are, on the average, indeed less efficient than the local firms.

Table 12: Panel Tobit MLE

Dependent Variable is *Metafrontier Technical Efficiency Estimates*

Explanatory Variables	Coefficients
Food	0.031 (0.007)***
Garments	-0.000 (0.009)
Wood	0.008 (0.008)
Metal	0.010 (0.007)
Large	0.020 (0.005)***
Medium	0.008 (0.003)**
Education	-0.000 (0.000)
Firms in capital city	0.014 (0.003)***
Gross profit	0.000 (0.000)***
Profit Rate (i.e. Return On Capital)	-0.000 (0.000)
Dummy for "foreign presence"	-0.034 (0.004) ***
Constant	0.087 (0.008)***

Source: Empirical results on Ghana's Manufacturing Industry Survey (1991-1997).

Figures in brackets are standard errors. ***, **, and * means significant at 1%, 5%, and 10%, respectively.

6.0 CONCLUSION

Based on the findings in the previous chapter, we draw the following conclusions and recommendations:

- The firm characteristics show that all the workers of the firms in the Ghanaian manufacturing industry are, on the average, adults with eight years tenure, and the entrepreneurs of the firms are not highly educated.
- All categories of firms with foreign presence made higher profits than their local counterparts. Moreover, only large firms made positive returns on capital for the whole manufacturing industry. Whilst only local large firms made positive returns on capital, both small and medium firms with foreign presence made negative returns.
- All firms of all groups and of all categories in the industry are less efficient. However, local firms have higher efficiency scores than firms with foreign presence.
- Local firms are closer to the potential output defined by the metafrontier function than firms with foreign presence.
- The stochastic frontiers for all the two groups of firms are tangent to the stochastic metafrontier. We also observed from the results of the categories of firms that, medium and large firms with foreign presence and local micro and medium firms are tangent to the stochastic metafrontier.
- Capital-labor ratio is too high for firms with foreign presence and too low for local firms. Thus, local firms need more capital in production whilst firms with foreign presence need more labor.
- Firms with foreign presence use more advanced technology than the local firms as indicated by the intercept term in the production function.
- It is observed from estimates of the Tobit model that, technical efficiency scores are influenced by food producing firms, large and medium firms, gross profits, dummy for foreign presence, and firms located in the capital city. The estimates also confirmed the frontier results that, firms with foreign presence are indeed less efficient than the local firms.

It is evident from this study that, firms with foreign presence/ownership performed significantly less than the local firms in Ghana within the period under study. Furthermore, firm size is important in the productive efficiency of the Ghanaian manufacturing. Our results also support earlier studies by Söderbom and Teal (2003) that technical inefficiency in Ghana's manufacturing sector is not lower in firms with foreign ownership. Thus, manufacturing firms in Ghana do not need foreign human capital but rather physical capital. We therefore recommend that foreign assistance to the Ghanaian manufacturing industry should rather be concentrated on physical capital.

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8.0 APPENDIX

Share of Manufacturing Output (1981 to 1999)

Year	*Manufacturing (%)*
1981	71.6
1982	59.7
1983	61.2
1984	61.8
1985	65.3
1986	67.3
1987	66.5
1988	65.1
1989	63.8
1990	63.2
1991	61.9
1992	59.8
1993	58.6
1994	57.6
1995	57
1996	56.9
1997	56.8
1998	57.2
1999	56.8

Source: Baah-Nuakoh (2003). Compiled from National Account Data; *Quarterly Digest of Statistics*, Various Issues. The computation adopted 1977 as the base.