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Productivity and Technical Efficiency of Cocoa Production in Eastern Ghana

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Abstract

This paper analyzes the productivity, technical efficiency and its determinants among cocoa producers in the Eastern region of Ghana. A multi-stage random sampling technique is used to obtain a cross sectional data on 190 respondents. The stochastic frontier model is adopted to analyze the research objectives. The results reveal that productivity level of cocoa responds positively to land size, the level of agrochemical, labour and intermediate input used. However, productivity responds negatively to the increasing age of the cocoa trees. Cocoa producers in the region exhibit decreasing returns to scale. The mean technical efficiency among the cocoa producers is estimated to be 85%, indicating that the possibility of enhancing production given the present state of technology and input level can be achieved in the short run by increasing technical efficiency by 15% through adoption of practices of the best cocoa farm. Exogenous factors such as access to extension services, technical support and credit are found to reduce the level of technical inefficiency among the producers. Also older farmers and male farmers are efficient than younger and female farmers. Farmers with more experience in cocoa production also produce with technical efficiency.

Key words: Cocoa, productivity, technical efficiency, stochastic frontier, Ghana

1.0 Introduction

1.1 Background and Problem Statement

Cocoa is one of the major foreign exchange earners for some African countries, such as Ghana, Cote d'Ivoire, Nigeria, and Cameroon. About 70% of the world supply of cocoa originates from Africa, and Ghana is the second largest world producer and supplier of cocoa after Cote d'Ivoire (Nkamleu et al., 2010). The cocoa sector in Ghana employs over 800,000 smallholder farm families, providing employment, income and a major source of foreign exchange for the country. Out of the 38% contributed by the agricultural sector to foreign exchange earnings in 2008, the cocoa sector constituted 28.5% compared to 5.9% and 3.6% contributed by timber and the non-traditional export sectors, respectively (ISSER, 2008). The farm size is relatively small, ranging from 0.4 to 4.0 hectare with an estimated total cultivation area of about 1.45 million hectares (Anim-Kwapong and Frimpong, 2005).

Productivity in the agricultural sector has been considered important to the development process. Productivity and efficiency improvements allow agrarian countries to produce more food at lower cost, and permit the release of resources to other sectors of the economy. Efficient resource utilization is sometimes hindered by the problem of limited access to resources together with the difficulty in the appropriate use of resources for production. The level of managerial and technical skills, level of capital utilization, commitment of labour force and the technology in use are some of the factors influencing resource use efficiency (Okezie and Okoye, 2006). Efficient use of resource is needed for cocoa producers to achieve their full productivity potential in order to bridge the imbalances of global demand and supply.

Cocoa yield in Ghana is about 400kg of cocoa per hectare whereas the potential has been estimated to be a 1000kg per hectare (Barrietos et al., 2008). The average yield of 400kg/ha compared to countries like Cote d'Ivoire, Cameroon and Nigeria puts Ghana as performing below its potential (Binam et al., 2008). This suggests that there is a need to develop interventions that will aim at boosting the productivity levels in cocoa production in the country. In a bid to enhance cocoa yield and productivity, the government of Ghana in consultation with other stakeholders, designed the Cocoa Sector Development Strategy (CSDS) in 1991. Under the strategy, cocoa production was projected to increase from 335,000 tonnes in 1991 to about 500,000 tonnes by 2004/2005 and then to 700,000 tonnes by 2009/2010. In 2010/2011 cocoa production in Ghana increased to 1,000,000 tonnes. However, this level has not been sustainable as it has been fluctuating. It is believed that this increase in the level of cocoa output has been attributed to a number of interventions including, the Cocoa Hi-tech initiative programme and increase in land size for cocoa production. This therefore raises the question of whether higher productivity and technical efficiency levels can be achieved in the cocoa sector with the introduction of these interventions. This paper generally analyzes the efficiency levels of cocoa producers in the Eastern region of Ghana. Specifically the levels of productivity and technical efficiency are estimated and the determinants of technical inefficiency are also identified and discussed.

2.0 Materials and Methods

2.1 Study Area, Data and Sampling Procedure

The underlying study of this paper was carried out in the Eastern region of Ghana which is one of the highest cocoa producing regions in the country. The region covers a total land area of 19,323 square kilometers representing 8.1% of the total land area in Ghana. The major economic activities are agriculture and related work (54.8%), sales/trade (14.3%), production, transport and equipment (14.0%), professional and technical work (6.9%) and service (5.0%). The soil type is that of savannah and supports the cultivation of crops such as cocoa, cola-nuts, citrus and oil palm, pineapple, and cassava In the 2009/2010 cocoa production season, the region produced about 60,000 metric tonnes of cocoa (www.ghanadistricts.org).

The study used cross sectional data from three cocoa producing districts in the Eastern region of Ghana. The districts were the Fanteakwa District, Suhum-Kraboa-Coaltar District and the East Akim Municipality. Consideration of the districts was based on the concentration of cocoa farms in these districts. Four communities were then selected randomly from each district. The number of respondents selected from the communities was based on the number of farms in each community. A list of farmers was obtained from the local offices of the Ghana Cocoa Board (COCOBOD) to aid this process. A total of 190 farmers were randomly selected from the list provided. A well structured questionnaire was administered to capture data on socio-economic characteristics of the cocoa farmers, and the levels of their production inputs and output.

2.2 Method of Analysis

2.2.1 Analytical Technique

The stochastic frontier Analysis (SFA) model adopted for this study allows for the decomposition of the error term into random error and inefficiency error rather than attributing all errors as random effects. In stochastic frontier analysis the firm or farm is constrained to produce at or below the deterministic production frontier. The approach is preferred for efficiency studies in agriculture because of the inherent stochastic nature of the agricultural systems (Ezeh, 2004; Coelli, 1995). The SFA was first proposed simultaneously by Aigner et al. (1977) and Meeuseen and Van Den Broeck (1977) and it is specified for a cross section as:

$$Q_i = f(\beta; X_i).\exp(v_i - u_i), \qquad u_i \geq 0 \tag{1}$$

Where: Q_i is the production of the ith firm, X_i, vector of input quantities of the ith firm, β, vector of unknown parameters to be estimated; v_i *is* assumed to account for random effects on production that is not within the control of the producer and u_i is a non-negative error term measuring the technical inefficiency effects that fall within the control of the decision unit.

The SFA has been used currently by authors like Onumah and Acquah (2010), Onumah et al. (2010), Nyagaka et al. (2010), Park and Lohr (2010) Dzene (2010), Nchare (2007) and Ogundari and Ojo (2007) and the approach specifies technical efficiency as the ratio of the observed output to the frontier output as shown in model (2):

$$TE = \frac{f(X_i;\beta)\cdot\exp(v_i - u_i)}{f(X_i;\beta).\exp(-v_i)} = \exp(-u_i) \tag{2}$$

Where $f(X_i;\beta)\cdot\exp(v_i - u_i)$ is the observed output and $f(X_i;\beta).\exp(-v_i)$. Following Battesse and Coelli (1995), the error term, v_i is assumed to be identically, independently and normally distributed with mean zero (0) and a constant variance σ_v^2; $\{v_i \sim N(0,\sigma_v^2)\}$. The error term, u_i is also assumed to be distributed as a truncation of the normal distribution with mean μ_i and variance, σ_u^2; $\{u_i \sim N(\mu_i,\sigma_u^2)\}$ such that the inefficient error term is explained by some exogenous variables specified as

$$\mu_i = Z_i\delta \tag{3}$$

Where Z_i is a vector of exogenous variables δ is a set of unknown parameters to be estimated.

In this research, the single-stage maximum likelihood estimation method is used in estimating the technical efficiency levels of the producers and the effects of the determinants of inefficiency simultaneously. This simultaneous estimation procedure ensures that the assumption of identical distribution of the u_i is not violated. The maximum likelihood estimation of the frontier model yields the estimates of β and the gamma (γ), where the γ measures the total variation of observed output from the frontier (deterministic) output. It is given as the ratio of the variance of the error associated with inefficiency (σ_u^2) to the overall variation in the model (σ^2). The overall variation of the model is the sum of the variance of the error associated with inefficiency (σ_u^2) and that associated with random noise factors (σ_v^2). The gamma estimate is expressed given as: $\gamma = \frac{\sigma_u^2}{\sigma^2}$ where the γ lies between zero and one ($0 \leq \gamma \leq 1$). The closer the value is to 1, the more the deviation of observed output from the frontier is as a result of inefficient factors; if the value is close to 0 then deviations are as a result of random factors. If the value lies in-between 1 and 0, then the deviation may be attributed to both random and inefficient factors.

2.2.2 Model Specification

The translog production function stated in model (4) is assumed for the study. It is a flexible functional form which places no restriction on the elasticity of production unlike the Cobb-Douglas model. The translog function has been proven by other studies to be efficient for technical efficiency (Onumah and Acquah, 2010; Baten et al., 2009).

$$LnQ_i = Ln\beta_o + \sum_{i=1}^{5} \beta_i LnX_i + \frac{1}{2}\sum_{i=1}^{5}\sum_{j=1}^{5} \beta_{ij} LnX_i LnX_j + (v_i - u_i) \qquad (4)$$

Where: Q_i = the level of output (Kilograms), X_1=Land size (hectares), X_2=Labour (man-days), X_3=Age of trees (average age of farm in years), X_4=Intermediate inputs (in GH¢), X_5=Agrochemicals (liters).

To measure the productivity levels of each of the technologies**,** the partial elasticity of production with respect to the individual inputs was computed from the translog production frontier model. The first order coefficients in model (5) are interpreted as direct elasticities since the variables were rescaled to have unit means.

$$\varepsilon_q = \frac{\partial \ln E(Q_i)}{\partial \ln X_{ji}} = \left\{ \beta_j + \beta_{jj} \ln X_{ji} + \sum_{i=1}^{n} \beta_{jk} \ln X_{ki} \right\} = \beta_j \qquad (5)$$

Returns to Scale (RTS) is also computed from the production function. The RTS is the sum of the elasticities of output for the various inputs, given as: $RTS = \sum \varepsilon_{qi}$

Decision rule: RTS>1 implies increasing returns to scale, RTS<1 implies decreasing returns to scale and RTS=1 implies constant returns to scale.

The model to explain inefficiency is specified as follows:

$$\mu_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 \qquad (6)$$

The mean of the error term $u_{i,}$ is explained by socio economic characteristics of the producer and exogenous factors. The variables are defined in the Table 1.

2.3 Hypotheses Tested

A number of hypotheses were tested to examine the adequacy of the specified model used, the presence of inefficiency and relevance of exogenous variables to explain inefficiency among the producers. Table 2 lists the hypotheses tested. The Generalized Likelihood ratio statistic was used to test the hypotheses. It is given as

$$LR(\lambda) = -2\left[\{\ln L(H_0)\} - \{\ln L(H_1)\}\right] \tag{7}$$

$L(H_0)$ and $\ln L(H_1)$ are the values of the likelihood functions derived from the restricted and un-restricted model (Null and Alternate hypothesis respectively). This has a chi-square distribution with degrees of freedom equal to the difference between the number of estimated parameters under the H_1 (unrestricted model) and H_0 (restricted model). However, where the test involves a γ, then the mixed chi-square distribution is used. The H_0 is rejected when the estimated chi-square was greater than the critical.

3.0 Results and Discussion

3.1 Hypotheses tested

Table 3 demonstrate that the decision to use the Cobb-Douglas model was rejected in favour of the translog since the *LR* statistics for all models were greater than the critical. This indicates that the results from the translog model are more accurate and consistent compared to that from the Cobb-Douglas model. The result of the second hypothesis reveal that the stochastic production function had a better fit to the data than the average production response function. The findings of the third hypothesis suggest that inefficiency effects are present in the model and so the decision to preclude them was rejected. Similar results have been obtained by Onumah et al. (2010).

3.2 Results of the Frontier Model

The gamma was estimated to be 0.77. This implies that most of the deviations in total output are largely as a result of inefficiency in input use and other farm practices, whereas random factors contribute 23% to deviations of actual output from the frontier output. Some of the random shocks could be unfavorable weather conditions, pest and disease infestation and statistical errors in data measurement and model specification. The parameter estimates of the frontier model are presented in Table 4.

3.2.1 Productivity Estimates

The productivity estimates are explained in terms of output elasticities**.** Output responded positively to all inputs (land size, labour, agrochemical, intermediate inputs) used except average age of the cocoa trees. Table 6 demonstrates that a percentage increase in land size, labour, intermediate inputs and agrochemical results in a 0.77%, 0.08%, 0.05% and 0.15% increase in cocoa output, respectively. However, a percentage increase in the age of the trees results in a 0.13% decrease in output. Similar results have been obtained by Danso-Abeam et al. (2012) and Aneani et al. (2011). The computed return to scale is revealed to be 0.93 (Table 6) which implies that the cocoa producers in the study area exhibit decreasing returns to scale. This means that with a percentage increase in all inputs used, output or productivity increased by 0.93% which is less than the proportionate increase in the factor inputs. This can be attributed to poor management of the farms as farmers may not be improving upon management the same way they are increasing the level of inputs used in production or probably the scale of operation may be too large for them to manage.

3.2.2 Level of Technical Efficiency

Findings show that majority (37.89%) of the producers operated with technical efficiency levels of 81-90% whilst 32.63% operated with technical efficiency index of 90% and above (Figure 1). However, few (6.32%) of them had technical efficiency scores below 60%. The analysis further illustrates that the mean technical efficiency of the cocoa producers in the study area is 85% as compared to 49% obtained in a study by Danso-Abeam et al. (2012) in parts of Western Ghana. This implies that on the average, cocoa producers in Eastern Ghana are 15% below the best practice frontier output given the existing technology and the available input in the region. This further implies that if the producers have to achieve a 100% technical efficiency level, then they will have to bridge the gap between their current performance level and the maximum potential performance of the cocoa industry, by addressing some inefficiency factors discussed in the next sub heading.

3.3 Determinants of Technical Inefficiency

The estimated level of technical efficiency among producers is not enough to derive recommendations for policy intervention. It is also necessary to identify the sources of variation in the technical efficiency estimates among the producers and quantify their effect. This was made possible by specifying an inefficiency model whose regressors are exogenous factors related to the production unit. The results are presented in Table 5.

Male farmers across the sample are less inefficient compared to their female counterparts. Similar results were obtained by Binam et al. (2008), Onumah and Acquah (2010), and Kibarra (2005). This result can be explained by the fact that female farmers are most unlikely to attend agricultural extension meetings because of household chores. Even when they are able to attend such meetings, they may be sidelined where their views and concerns may not be taken into consideration. Moreover, male farmers may have easy access to credit considering the fact that they own most assets in the household which could be used as collateral for accessing credit.

The number of years of experience in cocoa farming methods among the producers has negative influence on technical inefficiency. Thus, with more years of experience, farmers are able to apply good practices to minimize losses.

Consistent with studies of Binam et al. (2008) and Nyagaka et al. (2010), results of this study show that cocoa producers who have access to credit are less technically inefficient than those who did not have access to credit. This shows that credit accessibility is vital in improving the performance of cocoa producers. Interaction with the farmers revealed that due to the costly nature of agrochemicals they usually take cash credit from the cocoa purchasing clerk to purchase such inputs. Al-hassan (2012) obtained similar results in his studies on smallholder paddy farmers in Ghana.

An increase in the number of extension contacts with cocoa specific messages is expected to improve farmers' productivity and technical efficiency. The results show that farmers who had increased frequency of extension visits produced with less inefficiency compared to farmers who had few contacts with extension agents. This result is consistent with the study carried out by Nyagaka et al. (2010), Binam et al. (2008) and Al-hassan (2012). This implies that effective extension visits and supervision will go a long way to improve farmers' production efficiency. The Ghana Cocoa Board should be commended here in that the board recruited extension personnel specifically to meet the needs of cocoa producers in the country. Farmers interviewed were very pleased with their services when compared with previous extension service delivery. This informs us that it is not only the number of visits that matters but the content of the message carried to producers.

All producers interviewed belonged to one farmer group or the other. As a result, data was taken on producers who had group support in terms of labour supply, information transfer and financial aid. Producers who had such support were less technically inefficient compared to their counterparts who did not have any support at all. This implies that it is not all about belonging to a farmer group but as to whether there is mutual benefit in terms of providing support to each other in times of need or not. The results suggest that it is necessary for farmers in a group to give themselves mutual support since it reduces technical inefficiency. Producers who are not in any group are encouraged to form/join one.

4.0 Conclusion

With the general objective of estimating the levels of productivity and technical efficiency of cocoa producers in the Eastern region of Ghana, the study has shown that cocoa productivity increases by less than proportionate increase in all inputs except the average age of the tree. With Returns to Scale value of 0.93, cocoa producers in the region can be described as exhibiting decreasing returns to scale and producing inefficiently since the mean technical efficiency score is 85%. However they can be perceived as making efforts to produce with optimum (100%) technical efficiency level since they are only 15% away from their maximum potential. In addition, majority (70.52%) of the producers produced with technical efficiency scores above 80%, whilst only a few (29.48%) produced below 80%. Access to credit, years of cocoa production experience, extension contacts and group support were the factors found to reduce inefficiency among producers. Male farmers in the region were also found to produce with less inefficiency than female farmers. It is recommended that the cocoa producers adopt measures to improve upon their management skills on their farms. Some of the management issues may include applying the right quantity of fertilizers and agrochemicals as recommended by the CSSVD (Cocoa Swollen Shoot Virus Disease) control department and replacing aged cocoa trees with younger ones. Also cocoa producers are encouraged to form help groups so they can provide assistance among themselves. Access to credit should also be improved to ease some production constraints. Reaching famers with cocoa specific information on how to improve their production practices through extension services is also imperative in reducing technical inefficiency.

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Table 1: Inefficiency Variables Measurement with their Expected Signs

Variable	**Description**	**Measurement**	**Aprior sign**
Z_1	Sex of farmer	Dummy: 1=male; 0=female	-/+
Z_2	Educational level of farmer	Levels: 0=None; 1= basic (primary, JHS); 2=secondary (SHS, vocational, technical); 3=tertiary (college, university, polytechnics)	-
Z_3	Experience	Years	-
Z_4	Access to credit	Dummy: 1=access 0=no access	-
Z_5	Extension contact	Frequency	-
Z_6	Technical assistance	Dummy: 1=access; 0=no access	-
Z_7	Age of Farmer	Years	-/+

Table 2: Description of Hypotheses Tested

Hypothesis	**Description**
1. $H_0 : \beta_{ij} = 0$	Coefficients of the second-order variables in the translog model is zero
$H_1 : \beta_{ij} \neq 0$	Coefficients of the second-order variables in the translog model is not equal to zero
2. $H_0 : \gamma = \delta_0 = \delta_1 \ldots \delta_7 = 0$	There are no inefficiency effects
$H_0 : \gamma = \delta_0 = \delta_1 \ldots \delta_7 \neq 0$	There are inefficiency effects
3. $H_0 : \gamma = 0$	Inefficiency effects are non-stochastic
$H_0 : \gamma \neq 0$	Inefficiency effects are stochastic

Table 3: Results of Hypotheses Tested

Hypothesis	LR statistics (λ)	LR Critical ($\chi^2_{0.01}$/mixed $\chi^2_{0.01}$)	Decision
1. $H_0: \beta_{ij} = 0$ $H_1: \beta_{ij} \neq 0$	32.15	30.60	H_0 rejected
2. $H_0: \gamma = \delta_0 = \delta_1 \ldots \delta_7 = 0$ $H_1: \gamma = \delta_0 = \delta_1 \ldots \delta_7 \neq 0$	43.69[a]	5.41[b]	H_0 rejected
3. $H_0: \gamma = 0$ $H_1: \gamma \neq 0$	49.66[a]	20.97[b]	H_0 rejected

Table 4: Estimates of the Single Stage Maximum Likelihood Stochastic Frontier Model

Variable	Parameter	Coefficient	t-ratio
Constant	β_0	0.180	3.37***
Ln (Land size)	β_1	0.765	16.2***
Ln (Labour)	β_2	0.084	1.91**
Ln (Tree age)	$\beta 3$	-0.131	-2.95***
Ln (Int. inputs)	β_4	0.048	2.06**
Ln (Agrochemical)	β_5	0.157	3.53***
Ln (Land square)	β_6	0.478	2.29**
Ln (Labour square)	β_7	-0.034	-0.284
Ln (Tree age square)	β_8	-0.303	-3.00***
Ln (Int. input square)	β_9	-0.016	-0.294
Ln (Agrochemical square)	β_{10}	0.124	0.659
Ln (Land*labour)	β_{11}	-0.054	-0.458
Ln (Land*tree age)	β_{12}	0.186	2.38***
Ln (Land*int. inputs)	β_{13}	-0.059	-1.09
Ln (Land*agrochemical)	β_{14}	-0.261	-2.33**
Ln (Labour*tree age)	β_{15}	-0.205	-2.54***
Ln (Labour*int. inputs)	β_{16}	0.001	0.288
Ln (Labour*agrochemical)	β_{17}	0.122	0.950

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[a] Values of test for one sided error obtained from the FRONTIER 4.1 output of the ML estimates
[b] critical values under the mixed chi-square distribution

Ln (Tree age*int. inputs)	β_{18}	0.128	3.28***
Ln (Tree age*agrochemical)	β_{19}	0.031	0.291
Ln (Int. input*agrochemical)	B_{20}	0.079	1.58*
Gamma		**0.77**	
Log-likelihood function		**36.76**	
LR test for one-sided error		**49.66**	
Sigma square (σ^2)		**0.75**	

***, ** and * represents 1%, 5% and 10% significance levels respectively

Table 5: Estimates of the Inefficiency Model

Variable	Parameter	Coefficient	t-ratio
Constant	δ_0	1.362	1.69**
Gender	δ_1	-0.451	-2.17**
Educational level	δ_2	0.042	0.676
Experience	δ_3	-0.009	-1.41*
Credit access	δ_4	-1.418	2.79***
Extension contact	δ_5	-0.037	-3.65***
Technical assistance	δ_6	-0.565	-2.89***
Age of farmer	δ_7	-0.007	-0.931

***, ** and * represents 1%, 5% and 10% significance levels respectively

Table 6: Elasticity of output and returns to scale

Variables	Elasticity	t-ratio
Land size (Hectares)	0.765	16.2***
Labour (man -days)	0.084	1.91**
Age of trees (average age of farm)	-0.131	-2.95***
Int. inputs (value)	0.048	2.06**
Agrochemicals (Liters)	0.157	3.53***
RTS	**0.923**	

*** and ** represents 1%, and 5% significance levels respectively

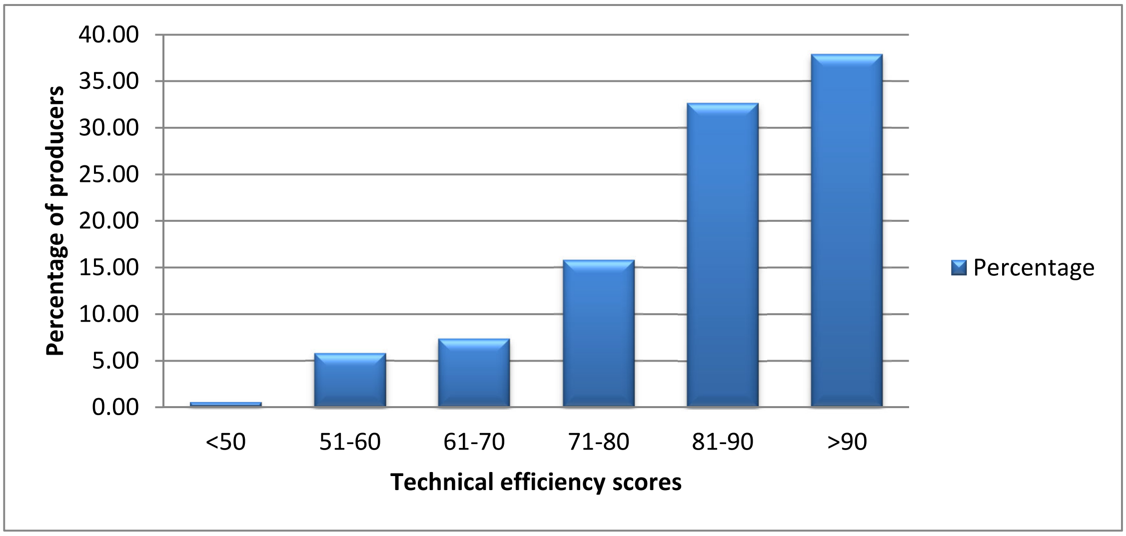

Figure 1: Technical efficiency scores

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