Meta-frontier analysis of organic and conventional cocoa production in Ghana

Justina Adwoa ONUMAH[1], Edward Ebo ONUMAH[2], Ramatu Mahama AL-HASSAN[2], Bernhard BRÜMMER[3]

[1]Science and Technology Policy Research Institute, Cantonments – Accra, Ghana
[2]Department of Agricultural Economics and Agribusiness, University of Ghana, Legon – Accra, Ghana
[3]Department of Agricultural Economics and Rural Development, Georg-August University, Göttingen, Germany

Abstract: This study considers the meta-frontier technique to compare the efficiency level of organic and conventional cocoa production systems in Ghana using a cross sectional data of 390 farms. The results reveal that the organic systems exhibit an increasing return to scale whilst, the conventional system exhibit decreasing returns to scale. All the inputs variables positively influence the production except the age of trees. The combined effects of operational and farm specific factors are identified to influence the technical efficiency although the individual effects of some variables are not significant. The mean technical efficiency relative to the meta-frontier is estimated to be 0.59 for the organic and 0.71 for the conventional farms. The study concludes that the conventional system of cocoa production is more technically efficient than the organic system. However, the increase in the scale of production in the organic system to take advantage of the economies of scale may enhance the efficiency of production.

Key words: returns to scale, stochastic frontier, technical efficiency, technology gap ratio

Cocoa (*Theobroma cacao*) is a very important perennial crop in Ghana and provides over 800 000 farmers with employment and serves as a major source of foreign exchange for the nation. Other stakeholders like chemical companies, input distributors and the Licensed Cocoa Buying Companies (LCB's) also depend largely on cocoa for markets of their products, and income (Asamoah and Baah 2003). Globally, there has been a growing demand for cocoa especially after the post-recession period in the Asia pacific. However, many cocoa producing nations are unable to meet the increasing demand as a result of the lack of resources and proper production mechanisms. This has created an imbalance between the demand and supply of cocoa in the world market and a resulting increase in producer prices. This unfolding paradigm served as an incentive for a significant increase in cocoa production in Ghana especially between 2004 and 2005 through the intensification of labour and non-labour inputs along with the increased land area cultivated. The government also played an important role by introducing a number of interventions including the extension information dissemination, the Cocoa Disease and Pest Control Programme (CODAPEC), the Cocoa Hi-tech initiative programme, the payment of the remunerative producer prices and the bonus payment scheme as a means of rewarding the farmers' effort in improving yields (Teal et al. 2006). The Cocoa Hi-tech programme was initiated to enhance the intensive use of fertilizers to replenish soil fertility, the application of pesticides on cocoa, and the adoption of the improved planting material to improve the productivity of cocoa farms.

However, the promotion of the use of high technology and the resulting growth in the cocoa output regarded as a form of green revolution may bring about problems of pollution, environmental degradation and lack of sustainability. Also, the synthetic fertilizer and chemical inputs use in cocoa production pose concerns about the health and safety of food products. These factors inspired another technological dimension to producing cocoa using organic materials. The organic cocoa production in Ghana started in 2007 and it is predominant in the Eastern region. The system depends on the low external input use, aimed at producing cocoa with the health and environmental sustainability as core values. The question therefore is whether this system will counter the objectives under the Hi-tech conventional system in the terms of increased productivity and efficiency. This necessitates an investigation into the performance of these two systems of cocoa production to identify which is the best measure to boost production. According to Nkamleu et al. (2010), the productivity levels of cocoa can be enhanced either by improving the technical efficiency and/or by improving the technological application. Onumah et al. (2010a) assert that the efforts to improve efficiency as the means of increasing agricultural output are more cost-effective than introducing new technologies if farmers are not optimising the use of the existing ones.

Few studies have been conducted on the efficiency of cocoa farmers in Ghana (Binam et al. 2008; Dzene 2010; Nkamleu et al. 2010). However, no comprehensive study has attempted to compare the level of efficiency between the organic and the conventional cocoa production. Additionally, the conventional efficiency studies usually consider production under a single technology using the Stochastic Frontier Analysis (SFA). There is a limitation to this estimation procedure when technologies are not similar in an industry. Such problems are prevalent in the situations where comparisons of farms/industries from different regions or groups are involved. The Meta-Frontier Analysis (MFA) is more appropriate for such comparative analysis when the technologies are dissimilar. The MFA has been applied by a number of researchers (Mariano et al. 2010; Moreira and Bravo-Ureta 2010) for the cross country and regional level of technical efficiency. However, few studies (Kramol et al. 2010) have considered the MFA for industries where different production technologies are involved.

Against this background, this paper seeks to comparatively analyse the technical efficiency levels of the organic and the conventional cocoa production systems in Ghana. In order to achieve this broad objective, the productivity level of organic and conventional cocoa production is analysed. The level of technical efficiency and the technology gap between these two production systems are also estimated. Finally, the determinants of technical inefficiency are identified and analysed.

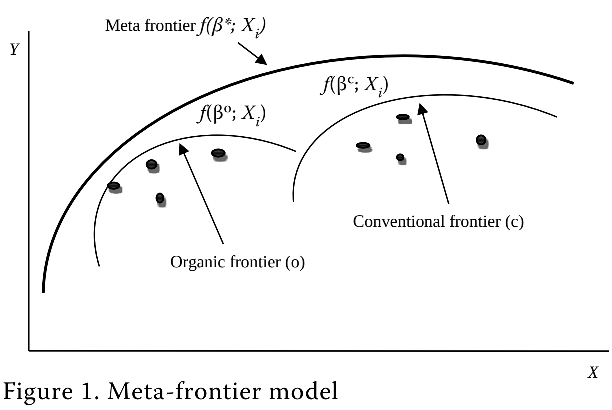

Figure 1. Meta-frontier model

Source: adapted from Battese et al. (2004)

MATERIAL AND METHODS

Building on the conventional stochastic frontier estimation model proposed by Aigner et al. (1977), Meeuseen and Van Den Broeck (1977) and Battese et al. (2004) propose the meta-frontier technique to investigate the technical efficiencies of firms in different groups with the same technology and firms under different technologies relative to a potential technology available to the industry as a whole. This study assumes the meta-frontier to be a smooth function that envelopes the two frontiers of the individual cocoa production systems as shown in Figure 1.

Considering the conventional system, the organic system and the pooled data represented by 'g', a standard stochastic frontier model is specified as:

$$Y_i = f(x_i; \beta^g)e^{v_i^g - u_i^g} \equiv e^{x_i\beta^g + v_i^g - u_i^g} \qquad (1)$$

where Y_i denotes the output; x_i denotes the vector of inputs; β^g denotes parameters to be estimated for the individual systems. The meta-frontier production function model for farms in the two production systems is expressed as:

$$Y_i^* = f(x_i; \beta^*) = e^{x_i\beta^*} \qquad (2)$$

where β^* denotes the vector of parameters for the meta-frontier function such that $x_i\beta^* \geq x_i\beta^g$. The v_i^g in model (1) is noise error, whilst u_i^g is the inefficiency error, assumed as the truncation (at zero) of the $N(\mu_i^g, \sigma_{u^g}^2)$ – distributions such that the mean μ_i^g is defined as in the model (3) to analyse the determinants of technical efficiency (Battese and Coelli 1995).

$$\mu_i^g = \delta_0^g + \sum_{m=1}^{M} \delta_m^g Z_{mi} \qquad (3)$$

The observed output for the i^{th} farm defined by the stochastic frontier for the production systems in equation (1), is expressed in terms of the meta-frontier function of equation (2) by

$$Y_i = e^{-U_i^g} \times \frac{e^{X_i\beta^g}}{e^{X_i\beta^*}} \times e^{X_i\beta^* + V_i^g} \qquad (4)$$

The first term on the right-hand side of model (4) is the technical efficiency relative to the stochastic frontier for the two production systems given by:

$$TE_i^g = \frac{Y_i}{e^{X_i\beta^* + V_i^g}} = e^{-U_i^g} \quad (5)$$

According to Battese et al. (2004), the technical efficiency of the i^{th} farm relative to the meta-frontier, denoted by TE^* is defined as the ratio of the observed output relative to the meta-frontier output, adjusted for the corresponding random error. This is expressed in a similar way as the model (5):

$$TE_i^* = \frac{Y_i}{e^{X_i\beta^* + V_i^g}} \quad (6)$$

The technical efficiency relative to the meta-frontier function can alternatively be expressed as the product of the technical efficiency relative to the stochastic frontier for the production systems and the technology gap ratio *(TGR)*: $TE_i^* = TE_i^g \times TGR_i^g$, where the TGR_i^g is the second term on the right-hand side of equation (4) expressed as:

$$TGR_i^g = \frac{e^{X_i\beta^g}}{e^{X_i\beta^*}} \quad (7)$$

The TGR_i^g indicates the gap between the given cocoa production technology and the technology available in the whole cocoa industry, and the higher the ratio, the closer the gap. It also gives the productivity potential for a production entity given the maximum potential in the industry as a whole (represented by the meta-frontier). The TGR_i^g is significant in explaining the ability of the individual farms in the organic group to compete with other farms in the conventional group. It corrects the technical efficiency scores of the producers that do not use the same technology and make them comparable using the distance between the technology (organic and conventional) frontier and the leading frontier.

Model specification

Due to the advantages outlined by Onumah et al. (2010a) concerning the translog production function, this study assumes this functional form for the study. Omitting the superscript *(g)* for simplicity, the translog functional form is specified as the model (8).

$$\ln Y_i = \ln\beta_0 + \sum_{j=1}^{5}\beta_j \ln X_{ji} + \frac{1}{2}\sum_{j=1}^{5}\sum_{k=1}^{5}\beta_{jk}\ln X_{ji}\ln X_{ki} + $$
$$+ (v_i - u_i) \quad (8)$$

where: Y_i = the level of output (kilograms), X_1 = land size (hectares), X_2 = labour (man-days), X_3 = age of trees (years), X_4 = intermediate inputs (GH¢ and includes fertilizers, cocoa sickles, baskets, cutlasses and pod breakers) and X_5 = agrochemicals (litres)

Thus the meta-frontier model is specified as:

$$\ln Y_i = \ln\beta_0^* + \sum_{j=1}^{5}\beta_i^* \ln X_{ji} + \frac{1}{2}\sum_{j=1}^{5}\sum_{k=1}^{5}\beta_{jk}^*\ln X_{ji}\ln X_{ki} + $$
$$+ (v_i^* - u_i^*) \quad (9)$$

The model to explain inefficiency is also specified as:

$$\mu_i = \delta_0 + \sum_{m=1}^{7}\delta_m Z_{mi} \quad (10)$$

where Z_1 represents gender which is a dummy variable which has the value of one, if the farm decision maker is a male, zero if she is a female; Z_2 denotes the educational level of farmer such that levels: 0 = none; 1 = basic (primary, junior high secondary); 2 = secondary (senior high secondary, vocational, technical); 3 = tertiary (college, university, polytechnics); Z_3 represents the experience of farmer, measured as the number of years of cocoa farming; Z_4 denotes the access to credit, which has the value of one for those who have access to credit or zero for those who do not have access to credit; Z_5 denotes the extension visit, measured by the frequency of extension contacts during the production year; Z_6 is group support (labour, financial, information dissemination) and it has a dummy of 1 for those with access and 0 for those without access; Z_7 represents the age of the farmer, measured in years.

Using a model proposed by Battese et al. (2004), this study estimates the parameters of the meta-frontier model by minimizing the sum of the squares of the deviations of the values on the meta-frontier from those of the individual stochastic frontier production systems at the observed input levels. A modified Ox programme developed by Brümmer (2003) is considered to obtain the maximum likelihood (ML) estimates for the parameters (Figure 1).

Hypotheses test

The following hypotheses are investigated to examine the adequacy of the specified model used, the presence of inefficiency, and the relevance of exogenous variables to explain the inefficiency for the conventional, organic and the pooled data. Also the appropriateness of the use of the meta-frontier is tested.

(1) H_0: $\beta_{ij} = 0$, that coefficients of the second-order variable in the translog model are zero, implying that the Cobb-Douglas function is the statistically valid representation of the data.

(2) H_0: γ = 0, the null hypothesis states that the inefficiency effects are non-stochastic. Under γ = 0, the stochastic frontier model reduces to the traditional average response function in which the explanatory variables in the technical inefficiency model are nested in the production function.
(3) H_0: $\gamma = \delta_0 = \delta_1 = ... = \delta_7 = 0$, the null hypothesis specifies that the inefficiency effects are absent from the models at every level.
(4) H_0: $f(X_i; \beta^0) = f(X_i; \beta^c)$, the hypothesis that the organic (*o*) and the conventional (*c*) technologies are the same and there is no need for the specification of the meta-frontier production model.

These hypotheses are tested using the generalised likelihood-ratio statistic; $LR = -2[\ln\{L(H_0)\} - \ln\{L(H_1)\}]$, where $L(H_0)$ and $L(H_1)$ are values of the likelihood function under the null (H_0) and alternative (H_1) hypotheses, respectively. *LR* has approximately a Chi-square (or mixed Chi-square) distribution if the given null hypothesis is true with a degree of freedom equal to the number of parameters assumed to be zero in (H_0). Coelli (1995) proposes that all critical values can be obtained from the appropriate Chi-square distribution. However, if the test of hypothesis involves γ = 0, then the asymptotic distribution necessitates the mixed Chi-square distribution (Kodde and Palm 1986; Table 1).

Table 1. Results of the hypotheses tested

Hypothesis	LR statistics (λ)	LR Critical ($\chi^2_{0.01}$/mixed $\chi^2_{0.01}$)	Decision
1. $H_0: \beta_{ij} = 0$ $H_1: \beta_{ij} \neq 0$			
Organic	82.89	30.60	H_0 rejected
Conventional	32.15	30.60	H_0 rejected
Pooled	90.20	30.60	H_0 rejected
2. $H_0: \gamma = 0$ $H_1: \gamma \neq 0$			
Organic	30.15[a]	5.41[b]	H_0 rejected
Conventional	43.69[a]	5.41[b]	H_0 rejected
Pooled	27.08[a]	5.41[b]	H_0 rejected
3. $H_0: \gamma = \delta_0 = \delta_1 ... \delta_7 = 0$ $H_1: \gamma = \delta_0 = \delta_1 ... \delta_7 \neq 0$			
Organic	63.28[a]	20.97[b]	H_0 rejected
Conventional pooled	49.66[a] 109.9[a]	20.97[b] 20.97[b]	H_0 rejected H_0 rejected
4. $H_0: f(X_{ki};\beta_k) = f(X_{ji};\beta_j)$ $H_1: f(X_{ki};\beta_k) \neq f(X_{ji};\beta_j)$			
Pooled only	145.50	52.19	H_0 rejected

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

Study area and sampling procedure

The study was conducted in the Eastern region of Ghana since it is the only region out of the six cocoa producing regions with both the organic and the conventional systems of production. Three districts are chosen for the study which includes the Suhum-Kraboa-Coaltar district, the East Akim district and the Fanteakwa district. A list of the registered Farmer Based Organisation (FBO) is obtained from the Yayra-Glover office and the Cocoa Swollen Shoot Virus Disease (CSSVD) control unit of the Ghana COCOBOD. A representative sample was selected randomly from the list and the farmers were interviewed with the aid of a well-designed questionnaire to obtain information on output, input, price data and exogenous variables. A total sample size of 390 is drawn for the study comprising of 200 organic cocoa farmers and 190 conventional cocoa farmers. In total, twelve communities were visited for the data collection. The proportion chosen for each community is based on the total number of registered farmers in the community out of the total sample needed for the study. Farmer groups with large numbers were given a higher proportion compared to farmer groups with smaller numbers. As a first step in the data collection, a pilot test was carried out to validate the suitability and appropriateness of the questions and the expected responses by the respondents. Revision of the questionnaire in the light of errors detected was carried out and omissions highlighted from the pilot survey.

RESULTS AND DISCUSSION

Hypotheses tested

The results of the hypotheses tested are presented in Table 1. The first hypothesis demonstrates that the decision to use the Cobb-Douglas model was rejected in favour of the translog for the organic, conventional and the pooled data. This indicates that the results from the translog model are more accurate and consistent. The second hypothesis that the inefficiency effects are non-stochastic is rejected, indicating that the stochastic production function was the most appropriate to use for all the models compared to the average production response function. Findings from the third hypothesis suggest that the inefficiency effects are present in all the models and so the decision to preclude them was rejected. Finally and core to this work, the null hypothesis that the technologies used under the conventional and the organic systems are the same is rejected, indicating that the organic and conventional cocoa producers do not share the same technology. Hence, the meta-frontier technique is the appropriate estimation approach for this study and that any efficiency comparison between these two production systems should be undertaken with respect to the meta-frontier instead of the pooled stochastic frontier. Similar results have been obtained by Battese et al. (2004); Binam et al. (2008); Mariano et al. (2010); Moreira and Bravo-Ureta (2010).

The stochastic frontier and meta-frontier estimates

The study revealed that the gamma estimate which measures the deviation of the observed output from the frontier output is estimated to be 0.96, 0.77 and 0.79 in the organic and the conventional systems and the pooled model, respectively (Table 2). This implies that in all the models, most of the deviations in the total output are largely as a result of the inefficiency in input use and other farm practices, whilst the random factors which may include unfavourable weather conditions,

Table 2. Parameter estimates of the stochastic frontier and meta-frontier models

Variable	Organic (ML)	Conventional (ML)	Pooled (ML)	Pooled (Meta)
Constant	0.233 (1.95**)	0.180 (3.37***)	0.394 (3.73***)	0.398 (6.93***)
Land size	0.501 (2.32***)	0.765 (16.2***)	0.513 (9.25***)	−0.038 (−0.273)
Labour	0.370 (2.27**)	0.084 (1.91**)	0.233 (5.83***)	0.388 (5.32***)
Tree age	−0.371 (−2.89***)	−0.131 (−2.95***)	−0.119 (−2.64***)	−0.129 (−2.44**)
Int. inputs	0.127 (0.766)	0.048 (2.06**)	0.069 (1.88**)	0.067 (1.37*)
Agrochemical	0.582 (6.90***)	0.157 (3.53***)	0.166 (3.43***)	0.672 (5.30***)
Land square	−0.659 (−3.03***)	0.478 (2.29**)	−0.205 (−1.33*)	0.021 (0.09)
Labour square	−0.185 (−1.70*)	−0.034 (−0.284)	−0.111 (−1.81*)	0.184 (1.61*)
Tree age square	−0.362 (−2.42***)	−0.303 (−3.00***)	−0.282 (−2.74***)	−0.174 (−1.49*)
Int. input square	0.195 (1.74*)	−0.016 (−0.294)	−0.001 (−0.010)	0.253 (1.82*)
Agrochemical square	0.849 (3.50***)	0.124 (0.659)	0.213 (1.74*)	1.31 (4.35***)
Land*labour	0.513 (2.50***)	−0.054 (−0.458)	0.277 (3.12***)	0.06 (0.36)
Land*tree age	−0.061 (−0.690)	0.186 (2.38***)	0.139 (1.15)	−0.208 (−1.53*)
Land*int. inputs	0.704 (4.58***)	−0.059 (−1.09)	−0.033 (−0.59)	0.373 (2.34**)
Land*agrochem	0.120 (0.966)	−0.261 (−2.33**)	0.232 (1.83*)	−0.485 (−3.46***)
Labour*tree age	−0.292 (−1.71*)	−0.205 (−2.54***)	−0.169 (−2.69***)	−0.212 (−2.16**)
Labour*int. inputs	−0.089 (−0.499)	0.001 (0.288)	−0.079 (−1.25)	0.081 (0.52)
Labour*agrochem	−0.458 (−2.31**)	0.122 (0.950)	−0.446 (−3.47***)	−0.363 (−1.54*)
Tree age*int. inputs	0.018 (0.135)	0.128 (3.28***)	0.096 (2.14**)	0.057 (0.58)
Tree age*agrochem	0.189 (1.68*)	0.031 (0.291)	−0.034 (−0.31)	0.455 (3.06***)
Int. input*agrochem	−0.684 (−3.08***)	0.079 (1.58*)	0.181 (1.73*)	−0.445 (−1.79*)
Gamma	0.96	0.77	0.79	
Log-likelihood value	8.28	36.76	−37.009	
Test of one sided error	63.28	49.66	109.79	
Sigma squared	0.90	0.75	0.76	
Mean T.E	0.80	0.85	0.68	

Values in parenthesis are the *t*-statistics; ***, ** and * represents significance at 1%, 5% and 10% levels respectively pest and disease infestation, statistical errors in data measurement and the model specification contribute by 4%, 23% and 21%, respectively to the deviations of the actual output from the frontier output.

Productivity responses of the output to the individual inputs in the respective organic and the conventional production systems are also presented in Table 2, but they are discussed in terms of the mean output elasticities (Table 3). Under both the organic and conventional systems, the study revealed that land size, labour, intermediate inputs and the level of agrochemical variables have a positive influence on production except tree age. This implies that as most of the cocoa trees increase in age, the productivity of cocoa falls as observed by Gray (2001). The negative effect of the tree age on productivity under both systems is a signal for producers to replace old trees with new ones. Table 3 also demonstrates that the coefficients for land across the organic, conventional and the pooled models have the largest partial elasticities, which implies that a percentage increase in the land size has a larger influence on the cocoa production than the same relative change on any other input.

Table 3 further demonstrates that the organic system exhibits increasing returns to scale of 1.21, indicating that a percentage increase in all inputs will result in a 1.21% increase in the level of output. This implies that the organic cocoa producers are in the stage one of the production function where increases in the level of all inputs used in production results in a greater than the proportionate increase in output. This result is an indication that there is more room for the organic cocoa sector to expand their scale to increase production in the long run. The conventional system, on the contrary, exhibits a decreasing return to scale of 0.92, which implies that a 1% increase in all inputs will results in only 0.92% increase in output. According to Vigneri (2007), higher levels of input productivity of cocoa are obtained on smaller farms. It is therefore not surprising that the organic farms which are relatively small in size compared to the conventional farms are exhibiting an increasing return to scale. It is possible that the conventional cocoa producers do not ensure the improvement in management techniques whilst considering the increases in the size of their operation.

Table 3. Output elasticities and returns to scale

Variables	Organic	Conventional	Pooled
Land size (hectares)	0.501	0.765	0.513
Labour (man – days)	0.370	0.084	0.233
Age of trees (average age of farm)	–0.371	–0.131	–0.119
Int. inputs (value)	0.127	0.048	0.069
Agrochemicals (Lit)	0.582	0.157	0.165
RTS	1.209	0.923	0.861

The meta-frontier estimates, however, show heterogeneity in the production technologies which results in significant differences in the estimated parameters between the stochastic pooled estimates and the meta-frontier estimates. All the estimates of the input variables in the meta-frontier model are positive in direction except for the average age of the cocoa farms and the land size (Table 2).

Technical efficiency and technology gap ratio

Farmers benefit directly from gains in the technical efficiency as such gains translate into improvements in incomes. The study reveals that the mean technical efficiencies from the stochastic frontier models are estimated to be 0.80 and 0.85 for the organic and conventional, respectively (Table 4). This implies that in the average, organic cocoa producers are 20% below their group frontier, whereas the conventional cocoa producers are 15% below their group frontier. 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 their systems by addressing some inefficiency factors.

Organic cocoa producers had a mean technology gap ratio (*TGR*) of 0.74, whereas their conventional counterpart had 0.84. The values of the TGRs indi-

Table 4. Technical efficiency scores and technology gap ratios (TGR)

	Min	Max	Mean	SD
Technology gap ratios				
Conventional	0.04	1	0.84	0.16
Organic	0.23	1	0.74	0.14
Pooled	0.04	1	0.79	0.15
Technical efficiency (stochastic frontier)				
Conventional	0.45	0.97	0.85	0.12
Organic	0.22	0.97	0.80	0.17
Pooled	0.19	0.95	0.68	0.16
Technical efficiency (meta-frontier)				
Conventional	0.04	0.96	0.71	0.17
Organic	0.12	0.90	0.59	0.16
Pooled	0.04	0.87	0.54	0.15

cate that if producers under the organic system were technically efficient, they could have increased the output by closing a gap of 26% whilst the conventional cocoa producers could have an increased output by closing a gap of 16%. The results imply that the conventional cocoa producers in Ghana are closer to the meta-frontier than their organic counterparts. This further implies that if all factors are held constant, the conventional cocoa producers will reach the maximum potential output for the cocoa producers in Ghana faster than their organic counterpart.

On the other hand, the mean technical efficiency scores for the organic and conventional producers relative to the meta-frontier are 0.59 and 0.71 respectively. This indicates that in the average, producers operating under the conventional cocoa system are more technically efficient than those operating under the organic system. This result suggests that the producers under the organic system need to increase their farmer learning pertaining to the use of the various inputs in order to match up with their conventional counterpart. The result obtained is consistent with Kramol et al. (2010), where the organic and safe-use farms had lower technical efficiency scores compared to their conventional and pesticide-free counterparts. Tzouvelekas et al. (2001) also observed low technical and economic efficiency scores among the organic cotton farmers compared to the conventional cotton farmers in Greece. This further suggests that organic producers in general have problems adjusting to the principles of the system and this translates to their low performance in the terms of technical efficiency which requires a maximum attention.

Determinants of technical efficiency

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

The study reveals that the male farmers in the study area are more efficient than their female counterparts. This implies that whether one is an organic farmer or a conventional farmer, males produce with higher technical efficiency levels as compared to female farmers. This result can be explained by the fact that female farmers are most unlikely to attend the agricultural extension meetings because of the household chores. Male farmers may also have an easy access to credit considering the fact that they own most assets in the household which could be used as collateral for accessing credit. Similar results are obtained by Binam et al. (2008); Onumah et al. (2010b).

It is conventionally expected that a higher attainment of formal education will enhance an individual's understanding of farming and the extension techniques directed at improving efficiency in production. Contrary to this expectation and results of the previous studies, this study demonstrates that producers with a higher education are less efficient than those with a lower level of education across the sample in terms of both the individual systems and the pooled sample. However, the education parameters are only significant among the organic producers and the pooled sample, but not with the conventional system. Binam et al. (2008) also observed a negative influence of education on technical efficiency in the pooled sample, but however had a positive influence on technical efficiency among the Ghanaian cocoa producers. Onumah et al. (2010a) in their study also observed a negative influence of the level of educa-

Table 5. Parameter estimates of the inefficiency model

Variable	Organic	Conventional	Pooled
Constant	–0.129 (0.341)	1.362 (1.69**)	1.235 (3.82***)
Gender	–0.457 (–2.87***)	–0.451 (–2.17**)	–0.224 (–1.74**)
Educational level	0.082 (1.59*)	0.042 (0.676)	0.045 (1.63**)
Experience	0.015 (3.06***)	–0.009 (–1.41*)	0.005 (1.25*)
Credit access	–0.109 (–0.877)	–1.418 (2.79***)	–0.234 (–1.04)
Extension contact	–0.021 (–1.78**)	–0.037 (–3.65***)	–0.015 (–1.56*)
Group support	–0.134 (2.29**)	–0.565 (–2.89***)	–0.072 (–1.21*)
Age of farmer	–0.018 (–3.96***)	–0.007 (–0.931)	–0.007 (–1.56*)

Values in parenthesis are the *t*-statistics; ***, ** and * represents significance at 1%, 5% and 10% levels respectively tion on technical efficiency in Ghana's fish farms. Nyagaka et al. (2010), however, observed a positive influence of education on technical efficiency in their studies. Thus, formal education may not necessarily improve one's technical efficiency but the level of one's knowledge and education pertaining to the practices of cocoa production that matters.

The number of years of experience in cocoa farming was expected to enhance technical efficiency. However, the model estimates suggest the contrary result between the organic and pooled sample. This could be attributed to the conservative nature of some experienced farmers. They may be so complacent with their traditional practices that have worked for them over the years and may not easily modify the use of innovative technologies. Also for the organic producers, an increase in the farmer learning would improve upon their technical efficiency but the farmers are only three (3) years into the organic practices and it may take time for them to adjust to the practice. This therefore suggests that for the organic farmers, it is not only the number of years of experience with the cocoa production in general that matters, but the increase in experience in the organic farming methods. On the contrary, the number of years of experience in the cocoa farming methods among the conventional producers had a 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); Nyagaka et al. (2010), the results of this study show that both organic and conventional producers who had access to credit were more technically efficient than those who did not have access to production credit. This shows that credit access is vital in improving the performance of cocoa producers. However, it only had a significant impact on the conventional producers and not the organic nor the pooled sample.

The increase in the number of the farmer-extension contacts with cocoa specific messages improved the level of efficiency in both groups of farmers compared to the farmers who had few or no contacts with the extension agents. This result is consistent with that carried out by Nyagaka et al. (2010) and Binam et al. (2008) for their pooled sample, but not for the Ghanaian sample. This may imply that the effective extension visits and supervision will go a long way to improve the farmers' production efficiency. In this respect, the Ghana COCOBOD should be commended for their efforts in recruiting more extension personnel specifically to meet the needs of cocoa producers in the country. Farmers interviewed were very pleased with their services when compared with the 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 whether the group members provide a group support to themselves and how this support in turn affected the technical efficiency levels of the producers. Across the organic, conventional and the pooled sample, farmers who had the group assistance in terms of labour supply; information transfer and financial aid were more technically efficient 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 a mutual benefit in terms of providing support to each other in the times of need or not.

Older cocoa farmers were revealed by this study to be more technically efficient compared to the younger ones. Dzene (2010) and Kramol et al. (2010) also reported similar results. The reason for this is that aged farmers may spend time attending the agricultural extension meetings and also listening to the agricultural radio programmes compared to younger farmers whose interest may be in recreations. Moreover, older farmers may have cocoa farming as their singular occupation to which they devote more time and attention compared to the younger farmers who may have other engagements such as trading, artisan activities etc. However, Mariano et al. (2010) reported that older farmers produce with more inefficiencies compared to younger farmers.

CONCLUSION

This paper considered the meta-frontier technique to compare the efficiency level of the organic and conventional cocoa production systems in Ghana using a cross sectional data of 390 farms. The results show under both the organic and conventional systems, the study revealed that all the input variables considered have a positive influence on production except the tree age. The study also reveals that among the organic farmers, productivity increases with more than the proportionate increase in the level of the factor inputs used, whereas among the conventional farmers, productivity increases with less than the proportionate increase in all inputs. This implies that the organic cocoa producers should endeavour to increase their scale of production with the effective management. Findings also demonstrate that the conventional cocoa producers are closer to the best practice technology compared to the organic cocoa producers, implying that the conventional cocoa producers are more technically efficient compared to the organic cocoa producers. Therefore, the potential for a further increase in output to meet the maximum potential output is much higher in the conventional technology than the organic. Further, the study notes that the combined effect of the operational and farm specific factors are identified to influence the technical efficiency although the individual effects of some variables are not significant.

This study therefore recommends that the conventional cocoa producers adopt measures to improve their management skills on their farms. Some of the management issues include applying the right quantity of fertilizers and agrochemicals as recommended by the CSSVD. Among all the cocoa producers, it is highly recommended that all aged trees must be replaced with new ones, by cutting down older ones and replanting with new ones, since it has been found to reduce the productivity across all the farms. It further recommends that the management and staff of the Yayra-Glover, who are spearheading the chart of the organic cocoa movement in Ghana, should intensify their farmer training so that the farmers catch up with their conventional counterparts. The organic cocoa sector is young and needs a lot of education on the principles and benefits so that farmers become familiar with the practices in order to bridge the gap between the organic and conventional cocoa producers.

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Contact address:

Justina Adwoa Onumah, Science and Technology Policy Research Institute, STEPRI – CSIR, P.O. Box CT. 519, Cantonments – Accra, Ghana
e-mail: justina.onumah@csir-stepri.org