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Full Length Research Paper

Does Global GAP Certification Influence Smallholders Technical Efficiency in French Beans production? A case study of Nyeri and Kirinyaga Counties, Kenya.

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Promoting productivity and output growth among small scale producers in Kenya would be a key contribution towards the achievement of the desired 10 percent annual economic growth rate. However, the production of French beans for the export market was challenged by the requirement to grow the produce under the GlobalGAP standard scheme and, thus, on farm-level technical efficiency. The objective of this study was to determine the technical efficiency of French beans grown under the GlobalGAP regimen. This was achieved by estimating the technical efficiency scores using the non-parametric data envelopment analysis (DEA) method followed by a second step double-bounded tobit analysis to determine which socio-economic characteristics influenced the technical efficiency. A survey conducted in November and December of 2013 captured input and output levels, and the socio-economic characteristics of a sample of 266 farmers in the Central region of Kenya. The technical efficiency of GlobalGAP certified farms was found to be lower than on non-certified farms, and the technical skills required by the farmers to improve the technical efficiency were influenced by the amount of agricultural trainings provided by extension agents. The analysis suggested that public investments directed at capacity building of the agricultural growers be increased.

Keywords: Factor usage, efficiency, GlobalGAP, small-holders, export market, extension.

INTRODUCTION

Increased productivity in subsistence and smallholder agriculture is a powerful engine of labour-intensive growth, income improvement, better access to food, a major contributor to poverty alleviation and equity improvement (McCalla, 1998). In Kenya, about 80% of the population lives in the rural areas and this translates to more than five million smallholders engaged in different types of agricultural activities (Government of Kenya, 2007). For these reasons, the Government of Kenya is focusing on agriculture as an important instrument for promoting national development (Horticultural Crops Development Authority, 2007). Vision 2030, Kenya's development blue print, mentions agriculture as one of the key sectors to deliver the desired 10 percent annual economic growth rate for the country (Government of Kenya, 2012). This development agenda supports the views posited by Bravo-Ureta and Pinheiro (1997) that an effective economic development strategy critically depends on promoting productivity and output growth in the agricultural sector, particularly among small scale producers.

Promoting productivity and output growth in the fresh produce sub-sector is challenged by the requirement to grow the produce under the GlobalGAP standard scheme. GLOBALGAP is a pre-farm gate standard which applies to the way products are planted, grown and harvested. It therefore has parallels to a process standard and it is also information laden (Chia Hui-Lee, 2008). As a quality management system, a farmer has to prove that s/he has the capacity to operate this system which requires the implementation of appropriate agronomic techniques (Humphrey, 2008). Thus, sophisticated planning and timing of input usage is imperative as the requirements to meet food quality and safety affect the choice of inputs (Rao *et al*, 2010). Meanwhile, increases in demand for fresh produce grown under GlobalGAP may influence input demand leading to higher input use (Rao *et al*, ibid). Yet, sustaining productivity gains will have to come from more efficient use of inputs, including land and labour (Pingali, 1998).

Acquiring information about the requirements of GlobalGAP and how to implement the scheme is unquestionably necessary for small-scale farmers' decision-making. Small-scale producers of French beans for the export market in Kenya rely on export companies for information on GlobalGAP requirements as the farmers would otherwise incur large fixed costs in order to acquire and process this information (Narrod *et al*, 2009). However, the linkages to export companies are usually exporter driven (Blakmore and MacGregor, 2011) and the export companies select the producers who will participate in production of export crops (Konig *et al,* 2011). The selection, however, does not lie in the efficiency advantage of any farmer, but on the exporters' sourcing strategies (Mutersbaugh *et al*, 2005).

Smallholders complying with the standard are expected to have high productivity and good quality produce which will reduce the level of rejection by the buyers and increase the returns (Asfaw *et al*, 2007). The dependence of small-scale farmers on export companies and the selection strategies of exporters can be viewed as a major constraint to increased productivity in the production of export bound French beans. These dynamics could also have important effects on farm-level technical efficiency.

Studies on the impact of GlobalGAP on the technical efficiency of small-scale farmers in Kenya were conducted during the first decade of the standard's adoption in the country. The studies focus on GlobalGAP as a new technology being introduced into export horticultural production. Okello *et al* (2007), Asfaw (2009) and Waweru *et al (*2009) focus on individual factor productivity while Rao *et al* (2010) focus on overall farm productivity through the application of a group frontiers approach. This study aims at adding to the literature on the effects of GlobalGAP on technical efficiency in the second decade since its introduction in 2002. More specifically, we focus on whether smallholders are efficient producers under a strict system of production such as GlobalGAP scheme. In this way, we seek to answer the question as to whether smallholders are capable of achieving higher productivity and output growth using the current levels of available resources on their farms. This is achieved by estimating the technical efficiency scores using the non-parametric data envelopment analytical (DEA) method (Coelli, 1995, 1996). This is followed by a second step analysis using a double bounded tobit model where the farmers' socio-economic characteristics are incorporated as probable influencers on efficiency (Bravo-Ureta and Pinheiro, 1997).

METHODOLOGICAL FRAMEWORK

Efficiency measurement begins with Michael Farrell in 1957 who proposed that the technical efficiency of a firm reflects the ability of a firm to obtain maximal output from a given set of inputs (Coelli, 1996). Farrell defined a simple measure of firm efficiency which could account for multiple inputs. This approach involves computing the efficiency frontier as a piecewise-linear convex hull in the input coefficient space to multiple outputs. Charnes, Cooper, and Rhodes (1978) reformulated Farrell's approach into calculating the individual input saving efficiency by the use of Data Envelopment Analysis (DEA) technique. The DEA model with it's input-orientation solves a linear programming problem for each decision-making unit (DMU) and calculates the individual input saving efficiency under the constant returns to scale (CRS) assumption The estimation equals 1 for efficient farms on the frontier, and then decreases with inefficiency. Banker, Charnes and Cooper (1984) extended Charnes *et al*'s (1978) technique to the case of variable returns to scale (VRS) in consideration of factors which may hamper a firm from operating on an optimal scale such as imperfect markets and capital constraints among other factors which were not included in the CRS assumption. Thus, both the CRS and the VRS models were suitable for this study since household farms tend to have greater control over their inputs than over their outputs.

Consistent with Coelli (1995), the constant returns to scale DEA model requires that for each household we obtain a measure of the ratio of all outputs over all inputs, uy_i/vx_i, where u is an M×1 vector of output weights and v is a K×1 vector of input weights. To select optimal weights, the mathematical linear programming problem is specified as:

$max_{u,v}(uy_i/vx_i)$

Subject to $uy_j/vx_j \leq 1$, j=1,2,...,N……………………….(1)

$u, v \geq 0$

The CRS-DEA model states that the optimal mix of inputs and outputs is independent of the firm's scale of operation. This implies that a proportionate increase in the inputs results in the same proportionate increase in the output (Tripathy *et al*, 2011). The objective function specified in (1) involves finding values for u and v so that the efficiency of the ith farm is maximized, subject to the constraint that all efficiency measures must be less than or equal to 1.

The above model is non-linear in nature and has an infinite number of solutions. Since linear programming cannot handle fractions, the above formulation needs to be transformed in such a way that the denominator of the objective function is limited and maximization of the numerator is allowed. For this purpose, an additional constraint is added. Thus, the above non-linear model transforms into the following linear model:

$max_{u,v}(\mu y_i)$

Subject to $vx_i = 1$

$\mu y_{j\,-}\, vx_j \leq 0$, j=1,2,............,N

$\mu, v \geq 0$…………………………….…………………(2)

where the notation changes from u and v to μ and v to reflect the transformation. By using the duality in linear programming which will enable the model yield efficiency scores that range between 0 and 1, we derive an equivalent envelopment form to the multiplier form of the linear programming problem, as follows:

$min_{\theta\,\lambda}\ \theta$

Subject to $-y_i + Y\lambda \geq 0$

$\theta x_{i\,-\,x\lambda.} \geq 0$

$\lambda \geq 0$ ………………………………………………………(3)

where θ is a scalar and is the efficiency score of the ith DMU. λ is a N×1 vector of constants. The value of θ will satisfy $\theta \leq 1$, with a value of 1 indicating a point on the frontier and, therefore, a technically efficient household as per Farrell's definition. The linear programming problem will need to be solved N times, once for each household in the sample and a value of θ will then be obtained for each household.

According to Coelli (1995), given there exist constraints on farms which do not allow them to operate at the optimal scale, using CRS would yield technical efficiency (TE) scores which are affected by scale efficiencies. Therefore, the variable returns to scale (VRS) model of DEA is used. VRS implies that an increase in inputs may result in either more or less than proportionate increase in the output. The CRS linear programming problem can therefore be modified to account for VRS by adding the convexity constraint on λ in equation (3). The final LP model to be estimated is as below:

$min_{\theta\,\lambda}\ \theta$

Subject to $-y_i + Y\lambda \geq 0$

$\theta x_{i\,-}\, X\lambda \geq 0$

$N1\lambda = 1$

$\lambda \geq 0$ ....(4)

where θ is a scalar and λ is an N×1 vector of ones. According to Coelli (1995), this approach would form a convex hull of intersecting planes which envelop the data points more tightly than the CRS conical hull, and thus provide technical efficiency scores which were greater than, or equal to, those obtained using the CRS model. The models were estimated using a user-written DEA computer program implemented in STATA version 12.0 to compute the technical efficiency scores.

Study area and sampling

According to Waibel (2011), any theoretically sound production economic framework for vegetables requires baseline information, and at a minimum, the productivity of the particular vegetable, as well as alternative cropping activities, must be known. In addition, information on the resource endowment of the farmers or households, depending on the type of system, is also needed, especially labour profiles as labour is a major input in vegetable production. To meet these requirements, the data used in this study came from a sample of farms in the Central region of Kenya. Nyeri and Kirinyaga Counties were chosen for this study because they had a long history of producing French beans for the export market, prior to, and after, the introduction of GlobalGAP standard in Kenya.

The two Counties surround Mount Kenya in south to west direction and were interspersed with permanent rivers. Altitude ranges were between 1,000 – 2,000 meters above sea level (a.s.l.) and the area experienced a bimodal rainfall pattern with long rains in March – May and short rains in October – December. Temperate conditions in the higher mountain ranges were suitable for vegetables and fruit growing while tropical agriculture was practiced, e.g coffee production, in the lower regions of the lower altitudes which experienced warmer temperatures. In the low lying areas of the southern region lay an extensive government-sponsored rice irrigation scheme. Horticultural crops were also grown in the irrigation schemes, enabling the farmers to produce these crops all year round.

Horticultural crops were the highest income sources for farm households. However, a wide range of crops were grown, either under rain-fed agriculture or by irrigation, in the areas lying wind-wards of the mountain, while lee-wards of Mount Kenya, the area was more favourable for livestock ranching. In the areas closer to the mountain, with cooler temperature ranges and water supply from permanent, down-flowing streams, horticultural crops were predominant. Vegetables grown all year round were French beans, kales, spinach, tomatoes, bulb onions, butternuts, pumpkins, capsicum (sweet pepper), and fruits, such as, water melons, mangoes, avocadoes and paw-paws. The main agricultural crops grown in the two Counties included tea, coffee, rice, maize, beans, bananas/plantains, and Irish and sweet potatoes (Ministry of Agriculture 2013a, b, c).

The study focused on small-scale farmers owing a maximum of 2.5 acres, and implementing a GlobalGAP compliant production system at the time of data collection in November, 2013. To be certified, an individual small-scale farmer was a member of a producers' group that maintained linkages with an export company. Thus, as a group, and in any production period, the farmers' were contracted as suppliers of French beans by an export company. The control group for the study was made up of farmers who were not GlobalGAP certified and were, therefore, excluded from group membership. This latter group consisted of those who had never been certified. However, in this group, some farmers had once been certified but had allowed their certification to lapse were identified. They were, therefore, considered to be non-compliant with GlobalGAP as were those who had chosen to discontinue in the process of gaining GlobalGAP certification.

Data was collected using a structured questionnaire which was designed for a single visit given the time and financial constraints. The questionnaire was designed in a way that farmers would provide farm and household characteristics to enable the assessment of the factors which influence the efficiency of smallholders growing French beans under a GlobalGAP compliant system. A sample size of thirty (30) farm households growing French beans were randomly selected from each location, making a total of 480 farm households for the study. After discarding 214 incomplete records, records which captured farms with more than 2.5 acres and other anomalies, a sample of 266 farms was used for the study.

Data and Empirical Production Frontier Model

For the frontier models, the explanatory variables were those commonly used in estimating agricultural production frontiers for developing countries as suggested by Bravo-Ureta and Pinheiro (1997). Data on input consumption and output production was used to evaluate the relative productivity of each firm/farm in the first stage while the contextual variables or socio-economic factors were independent of the input variables but correlated with each other as suggested by Banker and Natarajan (2008).

The model to perform the efficiency analysis was specified in general form as:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6) \quad (5)$$

where Y was the output and the X's were inputs. A detailed definition of the variables is presented below and descriptive statistics are presented in Table 1.

The output variable in equation (5), Y, was the farm value (in Kenya Shillings, KES.) of all crops produced on the farm, such as, coffee, bananas, rice, other vegetables including French beans. The variable X_1 included all cultivated land under French beans, that is, the size of the farm each household cultivated French beans. In some cases, this included rented land for individual farmers who had extend the permissible areas under French beans. Export companies were said to limit the farm size for French beans production to not more than 0.25 acres per farm in consideration of the production of food and other cash crops. The variable X_2 included family and hired labour measured in worker-days for the year 2013. On-farm labour was distributed between the various farm-operations ranging from land preparation to harvesting of all crops, thus, all available labour was used simultaneously in the production of all crops. X_3 represented the quantities of fertilizer used on the whole farm in 2013, measured in kilogrammes. X_4 corresponded to total expenditures on small farm tools for the year, and X_5 was the value of seeds and draft power used in the production process. An additional variable, X_6, was included in the model to represent the total expenditures on certification which included both the initial and recurring (annual) expenditures.

The technical efficiency (TE) results from the data envelopment analysis are presented in table 2. Both the VRS and CRS input-oriented efficiency measures were obtained mainly for comparison purposes. According to Coelli (1995), the VRS approach would provide technical efficiency scores which were greater than or equal to those obtained using the CRS model.

Table 1: Statistics of sample farms according to GlobalGAP compliance

Variable	Certified Farms (N=205) Mean (Std. Dev.)	Non-Certified Farms (N=61) Mean (Std. Dev.)	Difference in means	
			T	Sig. (2-tailed)
Allcrops (Y)	217 320.39 (180 135)	188 722.95 (145 921)	-1.134	.258
Land (X1)	0.91483 (0.87)	0.71721 (0.77)	-1.603	.110
Labour (X2)	218.63 (101.4)	195.11 (93.9)	-1.617	.107
Fertilizer (X3)	294.27 (751.3)	177.7 (221.9)	-1.195	.233
Tools (X4)	8 134.93 (7 676)	3 819.11 (4 126)	-4.210**	.000
Seed and draft power (X5)	35 726.81 (42 887.5)	32 922.95 (40 986.9)	-0.453	.651
GlobalGAP costs (X6)	27 699.57 (65 688)	0.00 (0.000)	-5.491**	.000

**Significant at the 0.05 level

Table 2: Frequency distribution of efficiency estimates from VRS and CRS DEA models

Efficiency level (%)	VRS-TE		CRS-TE	
	Frequency	Percent	Frequency	Percent
≤ 40	1	0.38	117	44.45
41 - 50	4	1.52	32	12.16
51 – 60	9	3.41	16	6.07
61 – 70	27	10.26	15	5.7
71 – 80	44	16.72	13	4.94
81 – 90	44	16.71	12	4.56
91 - 100	137	51.57	61	22.96
Mean	87.58		54.1	
Min	40.18		3.95	
Max	100		100	
Std. Dev.	14.46		30.98	
Coefficient of variation	16.5		57.26	

On the assumption of VRS-TE, the scores ranged from 40.17 to 100 percent, with a mean of 87.5 percent. The most technically efficient farm household was operating on the frontier in this model. However, for the average farm household in the sample to achieve the TE level of its most efficient counterpart, the average farm household would realize a 12.5 percent input savings (i.e., 1–[87.5/100]) without reducing output. A similar calculation for the most technically inefficient farm household revealed input savings of 59.8 percent (i.e., 1– [40.17/100]).

Under the CRS-TE assumption, scores ranged from 3.95 to 100 percent, with a mean of 54.1 percent. Again, the most technically efficient farm household was operating on the frontier. For the average farm household to achieve the TE level of the most efficient farm household, then the average farm household would achieve an input saving of 45.9 percent while the least efficient farm household would achieve an input saving of 96.05 percent without reducing its output.

The technical efficiency scores under the VRS assumption were higher than those under the CRS assumption as per Coelli's (1995) argument, and this result implied that, overall, one hundred and twenty farms were 100 percent efficient under the VRS model which captures market imperfections, among other constraints. Under the CRS model which presumes all the farms are operating at an optimal scale, fifty-four (54) farms exhibited 100 percent efficiency level. And in terms of variability, the efficiency scores from the VRS model were less variable than those from the CRS model as indicated by the coefficient of variation of 16.5 percent to 57.26 percent variation, respectively.

Table 3: Distribution of farms efficiency level according to GlobalGAP status

Frequency Level (%)	Non-Certified Farms Number	Non-Certified Farms Percent	Certified Farms Number	Certified Farms Percent
≤ 40	0	0	1	0.5
41 – 50	1	1.63	3	1.5
51 – 60	5	8.2	4	1.6
61 - 70	3	4.91	24	11.8
71 - 80	10	16.4	34	16.7
81 - 90	4	6.56	40	19.6
91 - 100	38	62.3	99	48.3
TOTAL No.	61	100	205	100

The differences in technical efficiency between certified and non-certified farms were analysed under assumption of VRS for the reasons mentioned above and are presented in Table 3. The results showed that 48.3 percent of certified farms were within the TE range of 91 to 100 percent while over 50 percent of non-certified farms were within this same range.

These results considered together with the general results presented in table 2, implied that farming French beans under a GlobalGAP certified system was not an efficient method of production in terms of the factors of production included in the efficiency models. GlobalGAP certified farms faced an additional cost of gaining and maintaining certification and this added cost could have been the source of inefficiency between the two categories of farms. This implied that even with the well intended benefits of group formation for reducing the costs of implementing a GlobalGAP farming regimen, at the farm-level, these costs were high for the smallholders and the cause of inefficiency. Cost issues relate to net gains, and high costs reduce net gains. Therefore, the income that may have been quoted by certified farmers may have taken into account these high costs which compressed their incomes downwards. This made for the significant differences in efficiency between certified farmers and their non-certified counterparts.

This analysis subsequently pointed to the matter of productivity gains which could be realized through improved efficiency. The results determined that the most technically inefficient farms could increase their efficiency by reducing their input usage by up to 59.8 percent for the same level of output. Productivity would, therefore, increase in French beans production through improved efficiency which this study determined was relatively low. However, factor usage was probably not the only constraint to the low efficiency. To identify any additional sources of inefficiencies entailed an investigation of the relationship between the farms/farmers characteristics and the computed TE indices in the second step analytical method.

The Empirical Second Stage Tobit Model

The efficiency scores obtained from DEA in the first stage became the dependent variables in the second stage of the Tobit model to identify the sources of inefficiency. According to related studies (Banker and Natarajan, 2008, Cooper et al, 2000, Macdonald and Moffitt, 1980), the productivity scores evaluated in the first stage are regressed on potential contextual factors or socio-economic factors in the second stage to identify the factors whose impact on productivity would be statistically significant. Since the DEA efficiency scores would lie in the interval 0 and 1, the dependent variable became a limited dependent variable. Therefore, it was apt to use the tobit model which is a censored regression model and applicable in cases where the dependent variable is constrained in some way.

Certain authors have considered alternative sets of assumptions for the two-step approach, such as Coelli (1995) and Bravo-Ureta and Pinheiro (1993). There are, however, critics of the two-step approach, more specifically, to the use of the tobit model in a second step. McDonald (n.d.) asserts that DEA efficiency scores are not generated by a censoring data generating process (DGP) and are, therefore, a particular kind of fractional or proportional data. Studies that refute McDonald's argument and support the two stage procedure in the case of non-parametric DEA models include Macdonald and Moffitt (1980), Banker and Natarajan (2008),Yu *et al* (2012) and Simar and Wilson (2011). Empirical studies utilizing this method include Ojimbo (2012), Hedeman (2014), and Tripathy *et al* (2011), among others.

The tobit model is defined as:

$$Y_i = \begin{cases} Y_i^*, & \text{if } 0 \le Y_i^* \le 1 \\ 0, & \text{if } Y_i^* < 0 \\ 1, & \text{if } 1 < Y^* \end{cases}$$

$$Y_i^* = \beta_o + \sum_{n=1}^{15} \beta n X_{in} + \varepsilon_i, \quad \varepsilon_i \sim N(0, \sigma^2)$$

$$\text{If, } L_i < \beta_o + \sum_{n=1}^{15} \beta n X_{in} + \varepsilon_i < U_i \quad \ldots\ldots (5)$$

where, Y_i is the observed dependant variable (the DEA efficiency score), $Y_i^*$is a latent variable representing the efficiency measure for each farm household, β is a k x 1 vector of unknown parameters to be estimated and which determine the relationship between the explanatory variables and the latent variable, and X_i is a

Table 4: Definition of the variables used in the tobit model and their hypothesized effects.

Variable	Definition and Units	Effects
X_1 Participation Dummy (*D*)	If farmer is certified (Yes = 1, No = 0)	(+, -)
Household characteristics (x_i)		
X_2 Age	Years	(+, -)
X_3 Gender	Dummy (male=1, female=0)	(+, -)
X_4 Education level of decision maker	No. of years of formal schooling	(+)
X_5 Family labour	Family labour non-remunerated (man-days)	(+)
X_6 Livestock assets	Total value of livestock	(+)
X_7 Household assets	Value of furniture, electronics, cell phones, etc.	(+,-)
X_8 Off-farm income	Income from businesses	(+)
X_9 Remittances and transfers	Average value of transfers and gifts received	(+)
X_{10} Exposure to information	No. of contact hours in the year with extension, NGOs and/or export companies in the year.	(+)
Farm/Firm characteristics (x_j)		
X_{11} Farm size	Farm size in acres	(+)
X_{12} Intermediate assets	Value of machinery and equipment	(+)
X_{13} Material inputs	Expenditure on stock (fertilizer, seeds, feeds, veterinary & crop chemicals)	(+)
X_{14} Hired labour	Hired labour on the farm (man-days)	(+)
X_{15} Market access	Distance to the market in kilometers	(-)

n x1 vector of explanatory variables for the ith farm. The model assumes that there is an underlying, stochastic index equal to $\beta X_i + \varepsilon_i$ which is observed only when it is positive, and hence qualifies as an unobserved, latent variable (Macdonald and Moffitt, 1980). L_i and U_i are the distribution's lower and upper censoring points, respectively.

A description of the variables used for analysis is presented in Table 4 showing the selected variables and the hypothesized influence of each variable on efficiency depending on the GlobalGAP status of each farm/farmer. Age was expected, theoretically, to reduce productivity because as people advance in age, their ability to commit to highly physical activities declines, and this negatively affects productivity. Lower productivity would, in turn, reduce income from farming and this was subsequently expected to limit the adoption of GlobalGAP farming system which demands annual and recurring costs. With respect to gender, as men seek employment in urban centers, their participation in agriculture was expected to decline leaving women as the active decision-makers on the farms. Women were expected to have better access to rural based information such as on GlobalGAP certification, and thus have a higher likelihood of adopting a GlobalGAP compliant farming regimen.

Education imparts skills that enable individuals to better conceptualize issues and combine resources in a more efficient manner. Wealth and exposure to information through seminars and contact with extension agents are associated with better access to input and product markets. Personal wealth, measured in the form of number of livestock, value of intermediate assets such as farm machinery and equipment, the amount of stock of material inputs such as fertilizer, seeds, feeds, and agricultural chemicals maintained, and ownership of household assets such as furniture, household electronics, and probably a personal vehicle, were hypothesized as being associated with better access to input and product markets. It was assumed that a household would increase its assets base from increased production and sale of farm produce and this was hypothesized to be an indicator of high efficiency levels. Engagement in non-farm activities was an important determinant of efficiency. On the one hand off-farm employment would increase the income base of the farm household, and therefore, increase the use of industrial inputs, while on the other hand, it would reduce the amount of labour available for agricultural production. This would consequently have a negative effect on efficiency. Contact with extension agents was hypothesized to have a positive influence on efficiency through better understanding of the requirements for production of French beans under GlobalGAP. Land size was hypothesized to influence efficiency negatively given the quantity of inputs used at the time. French beans production was a labour intensive process and both certified and non-certified respondents were expected to include hired labour to boost the contributions of family labour. Both labour amounts were hypothesized to have an ambiguous effect on efficiency. Income in the form of gifts and remittances would enable households to acquire consumptive goods as well as productive inputs, thus improving the efficiency of farms. Market access, measured in distance to the market, was theoretically expected to negatively influence productivity because distance relates to transaction costs both in input acquisition as well as output marketing. This would consequently lead to lower efficiency the further a farm was located from the market center.

The Tobit model was specified as:

$Y^* = \beta_0 + \beta_1 X_1 + \beta_2 X2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + \beta_{14} X_{14} + \beta_{15} X_{15} + \varepsilon_i$, i

i.e. using all the explanatory variables to investigate the relationship between efficiency and farmer characteristics. The model was implemented in STATA version 12.0.

RESULTS AND DISCUSSION

Results and Discussion from the Second Stage Tobit model

Table 5: Two-limit tobit marginal effects for factors that influence technical efficiency

Variables	**Model 1**		**Model 2**	
Dependent Variables	VTS TE (Certified Farms)		VRS TE (Non-Certified Farms)	
Independent Variables	Mean	Semi-elasticities	Mean	Semi-elasticities
age	48.40	-0.0025	46.05	-0.0027
Gender		0.066		0.065
Education in years	9.81	-0.029*	9.67	-0.0086
Family Labour	1 566.04	-0.0001	1 585.57	0.00
Livestock assets	65 984.78	-7.42e-07*	55 445.10	-7.68e-07*
Household Assets	45 979.34	0.00	40 050.57	0.00
Off-farm employment	86 989.01	0.00	107 903.30	2.11e-07*
Transfer gifts and Remittances	15 027.32	0.00	29 327.87	-4.78e-07*
Extension Contact	289.70	0.001*	179.60	0.00
Farm Size	1.57	-0.102	1.53	-0.062*
Small equipments and tools	6 323.56	0.00	10 772.46	0.00
Farm inputs held in stock	62 452.82	0.00	62 479.67	0.00
Hired Labour	1 819.08	-0.0001	1 925.90	0.00
Distance to local market	2.58	0.012	4.164	0.002
_cons	1.549		1.269	
No.of obs.	205 x 14 = 2 870		61 x 14 = 854	
LR chi^2	55.53		50.75	
Prob > chi^2	0		0	
Log likelihood	-92.68		52.15	

* Significant at the 0.05 level.

The results from the second step regression analysis are presented in Table 5 showing two models. Model 1 represents the GlobalGAP certified farms, and Model 2 for the non-certified farms. The results for each of the two models showed that the significant variables met the cut-off point of 5% significance level and the Prob > $\chi2$ was zero. This implied that the set of independent variables considered together satisfactorily explained the variations in the dependent variable.

The results for certified farms (Model 1) show that the education level of the household head, assets in the form of livestock, and the amount of time taken in attending training sessions together with the amount of contact hours with extension agents, significantly influenced the crop production technical efficiency. Education influenced efficiency negatively by reducing the TE score by 0.029. This result went against expectations since GlobalGAP was considered to be an information laden process and education, as a measure of the quality of human capital, would produce positive impacts on efficiency. However, this could be explained in the context that formal schooling was of a general nature which in turn was not significant to improving the technical management on-farm. This proposition would suggest that the technical skills required in agricultural activities would be more influenced by agricultural training via extension agents. This argument would be supported by the results which showed that training, the amount of contact hours with extension agents and attending agricultural workshops/seminars, were statistically significant and influenced the technical efficiency of certified farms positively. An alternative viewpoint to the positive and statistically significant influence of the amount of contact hours with extension agents to the technical efficiency of certified farmers was that there could be the transfer of knowledge at zero cost for non-certified farmers. According to this argument, non-certified farmers were benefiting from the agricultural trainings received by their certified neighbours and, therefore, becoming just as efficient as their certified counterparts. Thus, if we took these two scenarios as a given, then their influence on the efficiency gains for certified farmers would be higher, thus making the costs of maintaining a GlobalGAP certified farming system much higher. This would, therefore, be an important finding for intervention by extension and other stakeholders in this sub-sector.

Livestock ownership was found to reduce technical efficiency on certified farms. This implied that livestock ownership probably took away labour which would otherwise have been applied to the production of French beans and, therefore, reducing the technical efficiency.

The results for the non-certified farms in Model 2 showed that farm size, engaging in off-farm employment, transfers and remittances received and livestock ownership influenced efficiency were statistically significant, negatively. Land size was hypothesized to influence efficiency negatively given the quantity of inputs used as seen from the VRS TE analysis. For non-certified farms, this hypothesis proved correct. This result, however, lent support to the findings thus far that the quantities of inputs on the current land size were inordinately high and, therefore, needed to be reduced.

Engaging in off-farm employment was hypothesized to influence efficiency in any of two ways. The results were that off-farm employment for non-certified farms had a positive effect on efficiency and this implied that the additional income was significant with respect to the production of French beans. This result, however, contradicted the result for transfers and remittances which had a negative but significant influence on efficiency. Assuming that an increase in income from off-farm employment influenced efficiency positively, it was interesting to find that income from transfers and remittances had a negative influence showing that the results differentiated between the sources of the additional incomes. This was most confounding as we expected the source of income to be immaterial. In trying to find an explanation for this result, we argue that the additional income from transfers and remittances was probably used in the purchase of additional inputs which would subsequently lead to increased input usage. This would support our evaluation that input usage needed to be reduced in order to increase technical efficiency.

Livestock ownership also had an impact on the efficiency of non-certified farms as for certified farms. A large assets base, of which livestock was included, was presumed to be an indicator of high productivity, and was, therefore, expected to have a positive influence on efficiency. However, the results contrasted the hypothesis and livestock was found to have a significantly negative effect on efficiency due to the demand on labour away from French beans production activities.

CONCLUSIONS

Two broad conclusions were drawn on the impact of GlobalGAP standard on the technical efficiency of compliant and non-compliant farms. Firstly, the technical efficiency of GlobalGAP certified farms was lower than on non-certified farms. This was occasioned by the higher input usage reflected by the high stocks maintained on certified farms than on non-certified relative to the size of the farms. Thus, for efficiency to be increased, the usage of farm inputs needed to be reduced, and agricultural trainings conducted on-the-spot would contribute to ensuring this occurred.

Secondly, the years in formal schooling was argued to be of a general nature and not significant in improving the technical management on-farm. The technical skills required in agricultural activities would be more influenced by agricultural training via extension agents. This suggested that a mix of the two would lead to the increased productivity which the country is striving to achieve in its economic development policies. The ideal situation would then be to have farmers who were formally trained in agriculture in a hands-on or practical manner as is conducted in agricultural diploma colleges. While this may become a long term goal for the country, in the immediate term, we recommend that public investments directed at capacity building of the agricultural growers are increased as well as the numbers of extension agents working closer to the growers. This would effectively lead to increased productivity in the agricultural sector.

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REFERENCES

Asfaw S (2009). Impact of standards on income of small-

holders. Proceedings in ICIPE Workshop, Nairobi.
Asfaw S, Waibel H, Mithöfer, D (2007). What impact are EU supermarket standards having on developing countries export of high-value horticultural products? Evidence from Kenya. Presentation at the 105th EAAE Seminar on International Marketing and International Trade of Quality Food Products, Bologna.
Banker RD, Charnes A, Cooper WW (1984). Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis. Man. Sc., 30(9): 1078-1092.
Banker RD, Natarajan R (2008). Evaluating contextual variables affecting productivity using data envelopment analysis. Oper. Res., 56: 48–58.
Blackmore E, MacGregor J (2011). Private voluntary standards, co-investment and inclusive business. In *Vegetable Production and Marketing in Africa: Socio-economic Research*, eds. Dagmar Mithöfer and Hermann Waibel. UK: CABI, Oxfordshire.
Bravo-Ureta B, Pinheiro AE (1993). Efficiency analysis of developing country agriculture: A review of the Frontier Function literature. Agric. Res. Ec. Rev., 22(1): 88-101.
Bravo-Ureta B, Pinheiro AE (1997). Technical, economic and allocative efficiency in peasant farming: Evidence from the Dominican Republic. The Dev. Econs., 35(1): 48-67.
Charnes A, Cooper WW, Rhodes E (1978). Measuring the efficiency of decision making units. Eur. J. Oper. Res., 2: 429-444.
Chia-Hui Lee G (2008). Private food standards and their impacts on developing countries. Report for the European Commission DG Trade Unit G2.
Coelli TJ (1995). Recent developments in frontier modeling and efficiency measurement. Aust. J. Agric. Ec., 39(3): 219-245.
Coelli TJ (1996). A guide to DEAP Version 2.1: A data envelopment analysis (Computer) Program. Centre for Efficiency and Productivity Analysis (CEPA). Working Papers, 8/96. Armidale, Australia: University of New England.
Farrell MJ (1957). The measurement of productive efficiency. J. R. Stat. Soc., 120(3): 253-290.
Government of Kenya (2007). Kenya Vision 2030. Nairobi: Government Printers.
Government of Kenya (2012).The National Agribusiness Strategy 2012. Government Printers, Nairobi.
Hedeman YV (2014). Assessing efficiency of schools participating in Startsmart K3+". Paper 371.
http://digitalcommons.usu.edu/gradreports/371
Horticultural Crops Development Authority (2008). A report on domestic horticulture marketing and market infrastructure in Kenya. Nairobi: Imaging Centre.
Humphrey J (2008). Private standards, small farmers and donor policy: EurepGAP in Kenya. Institute of Development Studies. Working paper 308. UK.
König T, Blatt J, Brakel K, Kloss, TN, Woellert, F (2011). Value chains and regional trade in East Africa: The case of vegetables in Kenya and Tanzania. *Vegetable Production and Marketing in Africa: Socio-economic Research*. Dagmar Mithöfer and Hermann Waibel (eds), UK: CABI, Oxfordshire.
McCalla AF (1998). Agriculture and food needs to 2025. *International Agricultural Development*, 3rd edn. Maryland, US: John Hopkins University Press, pp.39-54.
McDonald J.(n.d.). Using least squares and tobit in second stage DEA efficiency analyses. Flinders Business School, Flinders University, Adelaide, Australia.
McDonald JF, Moffitt RA (1980). The uses of tobit analysis. Rev. Econ. Stats, 62(2): 318-321.
Ministry of Agriculture, Kenya (2013a). Crop statistics report, Mathira East sub-county.
Ministry of Agriculture, Kenya (2013b). Crop statistics report, Mwea East sub-county.
Ministry of Agriculture, Kenya (2013c). Crop statistics report, Mwea West sub-county.
Mutersbaugh T, Klooster D, Renard MC, Taylor, P (2005). Certifying rural spaces: Quality-certified products and rural governance. J. Rur. St., 21: 81-388.
www.elsevier.com/locate/jrurstud
ODI:10.1016/j.rurstud.2005.10.003.
Narrod C, Roy D, Okello J, Avendano B, Rich K, Thorat A (2009). Public-Private partnerships and collective action in high value fruit and vegetable supply chains. F. Pol., 34: 8-15.
Okello JJ, Narrod C, Roy D (2007). Food safety requirements in African green bean exports and their impact on small farmers. IFPRI Discussion Paper 00737, Dec. 2007.
Ojimba TP (2012). Socio-demographic factors as determinants of poverty in crude oil polluted crop farms in Rivers State, Nigeria. Int. J. F. Agric. Ec., 1(1):13-25.
Pingali PL (1998). Confronting technological consequences of the rice green revolution in tropical Asia. *International Agricultural Development*, 3rd edn. Maryland, US: John Hopkins University Press, pp. 474-493.
Rao EJO, Brümmer BB, Qaim M (2010). Farmer participation in supermarket channels, production technology and technical efficiency: The case of vegetables in Kenya. Presentation at the Agricultural & Applied Economics Association's 2010 annual meeting, Denver, Colorado, July 25-27, 2010.

Roncek DW (1992). Learning more from tobit coefficients: Extending a comparative analysis of political protest. Am. Soc. Rev., 57: 503-507.

Simar L, Wilson PW (2007). Estimation and inference in two-stage, semi-parametric models of productive efficiency. J.Economet. 136: 31–64.

Tripathy IG, Yadav SS, Sharma S (2011). Measuring the efficiency of pharmaceutical firms in India: An application of data envelopment analysis and tobit estimation. http://gcoe.ier.hit-u.ac.jp/CAED/papers/id062_Tripathy_Yadav_Sharma.pdf

Yu Y-S, Barros A, Yeh M-L, Lu M-J (2012). A study of estimating the technical efficiency of optoelectronic firms: An application of data envelopment analysis and tobit analysis. Int. J. Acad. Res. Bus. Soc. Sci., 2(7): 192-202.

Waibel H (2011). Theoretical concepts for socio-economic research of vegetables in Africa. *Vegetable Production and Marketing in Africa: Socio-economic Research.* Dagmar Mithöfer and Hermann Waibel (eds.), UK: CABI, Oxfordshire.

Waweru A, MacGregor J, Homer S, Vorley B (2009). Standard bearers, standard sharers: What private standards can reveal about sustainable trade with small-scale producers. Proceedings of ICIPE Workshop, Nairobi 5-6 March, 2009.