Factors Affecting the Efficiency of Smallholder Cotton Producers in Zambia

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ABSTRACT

Agriculture in Sub-Sahara Africa is considered as an engine of economic growth and has the potential to reduce rural poverty of smallholder farmers through increased food security and household income. However, most of Sub-Sahara Africa countries are faced with low agricultural productivity and this has undermined the potential to reduce rural poverty. The study focused on smallholder cotton producers in Zambia. Cotton is grown in Central, Eastern and Southern Provinces of Zambia and is an important cash crop which contributes over $60 million to the economy. It also supports over 150,000 households. However, productivity of smallholder cotton farmers in Zambia is low, around 800 kg per hectare or less. While in West Africa productivity is over 1000 kg per hectare. Agricultural productivity is defined as a measure of value of output for a given level of inputs. Efficiency is defined as the actual productivity of a farm relative to a maximal potential productivity. This shows that efficiency is related to productivity though it is productivity at maximum or minimum values. The study used the 2008 supplemental survey data collected by the Ministry of Agriculture and Cooperatives, Central Statistics and Food Security Research Project. Using Data Envelopment Analysis (DEA) this study determines the technical, allocative and economic efficiency indices of a sample of 812 (population estimates 150,801) cotton producers in Zambia. Using the Ordinary Least Squares (OLS) regression, the study determines the factors influencing technical, allocative and economic efficiency variations.

Results show that the mean technical, allocative and economic efficiency indices in cotton production are 46%, 37% and 20% respectively. This means that Zambian cotton farmers could reduce input use and production cost without altering the output by improving technical and allocative efficiency by 54% and 63% respectively. Female headed households, number of years spent in school by the household head, leaving crop residues, value of productive assets and off farm income are some of the factors found to positively influence the technical, allocative and economic efficiency.

The study found that cotton farmers are relatively inefficient and there is room to improve efficiency among smallholder cotton farmers in Zambia. Some socio-economic and farm specific factors have a positive influence on efficiency. The study recommends that cotton stakeholders should devise strategies of involving more women in cotton production, improve access to productive assets, and encourage adoption of conservation farming crop residue retention as the means to improve cotton production efficiency.

INTRODUCTION

In Sub-Sahara African countries, agriculture is considered as an engine of economic growth. It has the potential to reduce rural poverty of smallholder farmers through increased food security and improved household income. However most of the countries in Sub-Saharan Africa are faced with low agricultural productivity. Agricultural productivity has relatively stagnated in much of Sub-Saharan Africa for both land and labour productivity compared with other developing regions in the world[1-2]. Zambia, just like any other Sub-Saharan Africa country experiences low agricultural productivity despite it being endowed with abundant land resources of 75 million hectares and where 58% is suitable for agricultural production[3-4]. Even when the government liberalized the agricultural sector to allow private sector involvement in trying to improve agricultural efficiency and productivity, crop productivity has been stagnant. The study focused on smallholder cotton producers in Zambia. Cotton production and processing of seed cotton has grown rapidly after the reforms of the cotton sector in 1994 because of private companies' investments[6-7]. The crop is a cash crop and it contributes over US$ 60 million to the Zambian economy. The cotton sector supports over 150,000 households. However, productivity of smallholder cotton farmers in Zambia is low, around 800 kg per hectare or less. While in West Africa productivity is over 1000 kg per hectare which is relatively higher than in Zambia. Agricultural productivity is defined as a measure of value of output for a given level of inputs[2]. This study will focus on determining efficiency which is defined as the actual productivity of a farm relative to a maximal potential productivity[5]. This shows that efficiency is related to productivity though it is productivity at maximum or minimum values. Reviewing the literature it shows that a lot of studies have been done in Zambia that have looked at the impact of cotton sector reforms on the performance of the sector[6-8]. None has looked at efficiency levels and factors affecting efficiency in cotton production. Internationally, studies looking at the efficiency and the factors influencing efficiency have been done, though none has determined the impact of specific farm factors on technical, allocative and economic efficiency[9-12]. Specific farm factors include tillage systems used, land holding

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size, location, and seed varieties. A substantial knowledge gap remains on farm specific factors that influence efficiency in cotton production. Therefore, the objectives of this study are to determine technical, allocative and economic efficiency and to determine the factors affecting the technical, allocative and economic efficiency levels. Understanding the relationships between efficiency levels and socio-economic and farm factors could help policy makers to design and formulate strategies that would improve seed cotton production and productivity among the smallholder cotton farmers in Sub-Saharan Africa and specifically Zambia.

STUDY MATERIALS METHODS

Data Sources

This study is based on the cross-sectional data drawn from a nationally representative farm household survey conducted in Zambia in 2008. Undertaken by Zambia's Central Statistical Office, Ministry of Agriculture and Cooperatives and Food Security Research Project, the survey was designed as an in-depth supplement to the post harvest survey of 1999/2000. With a sample size of 8094 households and a total number of households represented by the survey, properly weighted, being approximately 1,669,861 households. For the purpose of this study, the sample for data analysis included cotton producing households from Central, Eastern and Southern Provinces where most of cotton growing households are found[13]. The sub-sample size is 812 households and when weighted, the population estimate is 150,801 cotton households. This is the sample on which the analysis was based. The prices of planting seed were obtained from the ginning companies while the prices of land and labour were obtained from the survey data. The inputs used in determining efficiency included: size of a cotton field measured in hectares, quantity of planting cotton seed measured in kg, and household labor measured in adult equivalent. Labour available for the household was measured in terms of adult equivalent. To determine adult equivalent, age and gender of household members were used and this is based on the World Health Organization has highlighted by[14].

However, one limitation on the inputs used in Data Envelopment Analysis (DEA) analysis is the lack of quantities of chemicals (pesticides) applied in a field of cotton. That variable was not collected in the supplemental survey. Despite the above limitation, the research was still adequate and efficient enough to bring out unbiased and required information for policy implication in cotton production in Zambia.

Methods

The method used in this study is called a two staged approach[15-22]. The first approach was used to determine efficiency scores using a variable returns to scale Data Envelopment Analysis (DEA) model. While in the second approach, Ordinary Least Squares (OLS) regression was used to determine the factors influencing efficiency.

The Variable Returns to Scale DEA Model (First Step Approach)

A non-parametric method Data Envelopment Analysis was used to determine the efficiency of the DMUs. In this process DEA approach identifies DMUs based on the technical and allocative efficiencies. Technical efficiency for production unit *h* (TE^h) is found by comparing unit *h* with a combinations of all other production units and establishing the minimum proportion of inputs that would allow unit *h* to produce the level of output actually being produced by *h* (18,20). Technical Efficiency coefficients can either be maximized or minimized. Depending on whether a maximized or minimized method is used, the level of efficiency scores that would be generated would be the same. To use the minimization methods is possible to aggregate the constraint and replace the objective function with one minimizing the sum of technical efficiency coefficients. The mathematical linear programming used to determine each household/farm technical efficiency measure is given as:

$$\min \sum_{h=1}^{z} TE^{h} \qquad (1)$$

$$\text{s.t} \sum_{h=1}^{z} \lambda_t^h y_s^t \geq y_s^h \qquad \text{for } s = 1,\ldots\ldots m : h = 1\ldots\ldots z; \qquad (2)$$

$$\sum_{h=1}^{z} \lambda_t^h x_g^i \leq TE\, x_g^h \qquad \text{for } g = 1,\ldots\ldots n; h = \ldots\ldots\ldots\ z \qquad (3)$$

$$\sum_{h=1}^{z} \lambda_t^h = 1 \qquad \text{for h}=,\ldots\ldots\ldots\text{z} \qquad (4)$$

$$\lambda_t^h \geq 0, \qquad \text{for } h =,\ldots\ldots\ldots z;\ h = 1,\ldots z; \qquad (5)$$

$$TE^{h} \geq 0 \qquad \text{for } h = ,\ldots\ldots\ldots\ z \qquad (6)$$

Source: Fried et al. 2008, Fletschner et al. 2002

Based on each individual equation above and where there are *m* outputs and *n* inputs, y_z^h is the s^{th} output of unit *h*, and x_g^h is the g^{th} input of unit *h*. The combination of units against which unit *h* is compared is given by the vector $\lambda^h = (\lambda_1^h, \ldots, \lambda_h^h, \ldots, \lambda_2^h)$ is the weight of each of the z units in the combination. In other words, λ^h is a (*h x 1*) vector of weights attached to each of the farm/firm (DMUs). The weighted outputs and inputs of these units against which unit *h* is compared are given by $\sum_{t=1} \lambda_t^h y_s^t$ and $\sum_{t=1} \lambda_t^h x_g^t$ respectively, where Y_s^t denotes the production of output *s* for each of the *t=1,………z* units, and x_g^t denotes the endowments of inputs *g* for each of the *t=1,….z* units. The first set of constraints requires that the weighted average of the output of all cotton farm (DMUs) ($\sum_{t=1} \lambda_t^h y_s^t$), less the output of the h^{th} cotton farm be greater than or equal to zero. This means that, the output of each cotton farm produced by the combination of production units has to be at least *h*'s output units. Similarly, the second group of constraint requires that combining production units in the same manner, the inputs used not do not exceed unit *h*'s level of inputs. The third constraint ($\sum_{t=1} \lambda_t^h = 1$) ensures that an inefficient cotton farm is only benchmarked against cotton farms of similar size, that is, the projected point (for that DMU) on the DEA frontier is a convex combination of observed DMUs. What makes the difference between the constant returns to scale (CRS) and the variable returns to scale (VRS) is the imposition of the third constraint (convexity restriction). The convexity restriction is not imposed in the CRS case. Hence as observed in the CRS case, a firm may be benchmarked against firms which could be substantially smaller or bigger than it[23].

$$\min_{X^*,\lambda^h} \sum_{h=1}^{z} w^h x^h \qquad (7)$$

$$\text{s.t} \sum_{h=1}^{z} \lambda_t^h y_s^t \geq y_s^h \qquad \text{for } s = 1,......m : h = 1.......z; \qquad (8)$$

$$\sum_{h=1}^{z} \lambda_t^h x_g^i \leq TEx_g^{*h} \qquad \text{for } g = 1,......n; h = ...z \qquad (9)$$

$$\sum_{h=1}^{z} \lambda_t^h = 1 \qquad \text{for h=,..........z} \qquad (10)$$

$$\lambda_t^h \geq 0, \qquad \text{for } h =,..........z; h = 1,....z; \qquad (11)$$

Source: Fried et al. 2008, Fletschner et al. 2002

Apart from the technical efficiency, there are other measures of efficiency. One of them is allocative efficiency measure which indicates the extent to which a production unit minimizes the costs of producing a given output vector, given the input prices it faces. Therefore, to calculate the allocative efficiency index, it is necessary to find the minimum cost, given input prices, output levels, and technology. As the case of technical efficiency measures, the *z* individual linear programs used to calculate the minimum costs for each of the *z* households are combined into a single computationally efficient linear program as shown in equation number 2 above where w^h is an n-vector of inputs prices, x^{*h} is the least-cost input combination for household *h*, and $w^h x^{*h}$ is the minimum cost that would allow household *h* to produce the same output level given the available technology. Having obtained the minimum cost for each of the *z* households, the allocative efficiency measure for the household *h* (AE^h) is given by the ratio of the minimum or optimal cost and the farm *h's* observed costs if they had been technically efficient as indicated below:

$$AE^h = \frac{C^{*h}(w^h, \gamma^h)}{(TE^h w^h x^{*h})} \qquad (12)$$

where $c^{*h}(w^h, y^h)$ is the optimal cost while $(TE^h w^h x^{*h})$ is the observed cost for producing the product. Therefore, the first step approach generates the efficiency scores based on the different parameters such has farm sizes, quantity of planting seed, pesticides, and insecticides, amount of labour used.

Table 1: Summary Statistics for the variables used in DEA

	N	Min	Max	Mean	Std Dev
Production of seed cotton in kg	150801	30	45500	838	1898
Area of seed cotton in ha	150801	.13	20	0.95	1.0
Adult equivalents	150801	.56	25	5.4	2.5
Qty of seed cotton planted in kg	150801	3.00	360	20	20

Source: Author's calculations (with population weights applied)

Second Stage using the Ordinary Least Squares (OLS)

After calculating the efficiency measures, the next step is to express the efficiency indices as the function of socio-economic and farm specific factors. This is known as the second stage procedure. It has been used by several researchers in determining the factors affecting efficiency[15-22]. The regression models that could be used in the second stage procedure are the Tobit, OLS and MLE. However, these models were reviewed using efficiency scores generated by either censoring or generated as fractions and made suggestions under which each one is appropriate[15-17]. In these separate studies, the conclusion was that Tobit is suitable to be used in the second stage when efficiency scores are generated by data censoring process otherwise it is an inconsistent estimator[24]. However, when efficiency scores are generated by using DEA where efficiency scores are not censored or corner solution data, but are fractional data the most suitable models are Maximum Likelihood Estimator (MLE) or Ordinary Least Squares (OLS).

Based on these studies[15-17], this study used Ordinary Least Squares (OLS) in the second stage procedure to determine the socio-economic and farm specific factors that are likely to influence efficiency in smallholder cotton production in Zambia. Ordinary Least Squares model is given as:

$$y_i = x_i \beta + u_i \qquad (13)$$

where y_i represents the efficiency scores, and x_i represents the socio-economic and farm specific factors that are likely to influence efficiency in cotton production and u_i is the error term. As indicated before, the efficiency scores lie from 0 and 1 and y_i is denoted as: $0 \leq y_i \leq 1$ with limit point $y_i = 1$ implying that the cotton farm is technically or allocatively or economically efficient. But where $0 > y_i < 1$, the cotton farm is inefficient.

RESULTS AND DISCUSSION

Descriptive Statistics, Efficiency and Regression Results

Table 2 shows the descriptive statistics of the household. The results show that 14% of the household heads are females and the mean age of the household head is around 46 years of age. The mean number of years spent in school by the household head is 5 years. This indicates low level of formal school attainment. There are four varieties (F135, *Chureza, Ngwezi,* CDT II) of seed cotton planted by smallholder cotton in Zambia. 75% of smallholder cotton farmers use *Chureza* cotton, followed by Ngwezi at 19% and then F135 at 16%. The least used variety is CDT II at seven percent. Tillage systems used for land preparation are conservation tillage systems (planting basins, ripping), ploughing, handhoe and ridges. Ploughing is the most used tillage system at 41% followed by ridges at 38%.

The mean efficiency scores are shown in Table 3. The predicted technical, allocative and economic efficiency of cotton farmer in Zambia ranged between 9% and 100%,7% and 100%, 1% and 100% with means of 46%, 37% and 20% respectively. The mean efficiency scores estimated in this study are lower than 58%, 60% and 79% estimated by studies done in Cameroon, Turkey and Dominican Republic

Table 2: Socio-Economic and Farm Level Factor of Cotton Households

Variables	N	Min	Max	Mean	Std Dev
Socio-Economic Factors					
Gender (Male=1, 0 otherwise)	150801	0	1	.86	.33
Mean age of Household head	150801	16	92	46	14
Head's Education level	150801	0	18	5.0	3.33
Mean # of Prime adults	150801	0	17	3.2	1.71
Farm level Factors					
Land Holding Size (ha)	150801	.38	29.97	2.56	2.18
Number of Weedings	150801	.00	7.00	3	.89
CF tillage	150801	.00	1.00	.06	.23
Handhoe	150801	.00	1.00	.16	.37
Ploughing	150801	.00	1.00	.41	.49
Ridges	150801	.00	1.00	.38	.49
Planting seed - F135	150801	0	1	0.16	.38
Planting seed - Chureza	150801	0	1	0.75	.44
Planting seed - Ngwezi	150801	0	1	0.19	.13
Planting seed - CDT II	150801	0	1	0.07	.25
Value of Productive Assets in ZMK (000,000)	150801	.00	132	4.4	9.3
Net Off-farm Income in ZMK (000,000)	150801	0.2	105	4.1	6.7

Source: Author's calculations (with population weights applied)

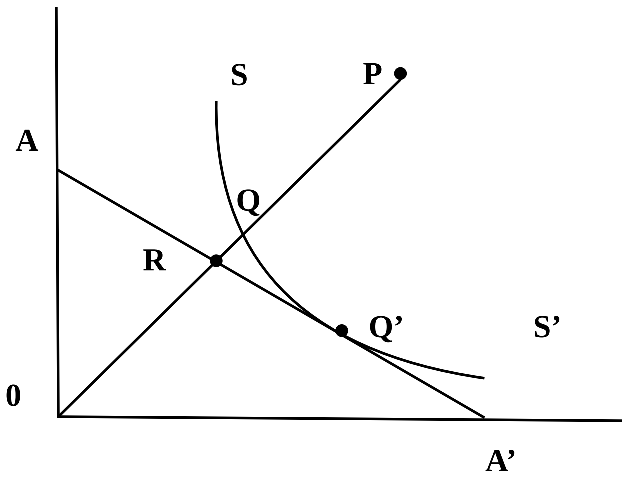
Table 3: Mean Technical, Allocative and Economic Efficiency Indices

	N	Mean	Std Dev	Min	Max
Technical Efficiency	150801	0.50	0.19	0.09	1.00
Allocative Efficiency	150801	0.41	0.17	0.07	1.00
Economic Efficiency	150801	0.24	0.19	0.01	1.00

Source: Author's Calculations with weights applied

respectively [9, 11, 25]. From the efficiency point of view this means that there was technical, allocative and economic inefficiency among cotton farmers. If cotton farmers were operating at full technical efficiency level, they could reduce on average the physical amount of inputs use by the tune of 54% without reducing production of seed cotton. With allocative efficiency of 37%, this could suggest that cotton farmers lack revenue maximization behavior and if they operated at full allocative efficiency they could reduce the cost of producing seed cotton by 63% without reducing the level of output. A product of technical and allocative efficiency results to economic efficiency. The result on economic efficiency shows that if a typical Zambian cotton farmer was to reach economic efficiency level of its economic efficient counterparts, the farmer could save 80% of production cost.

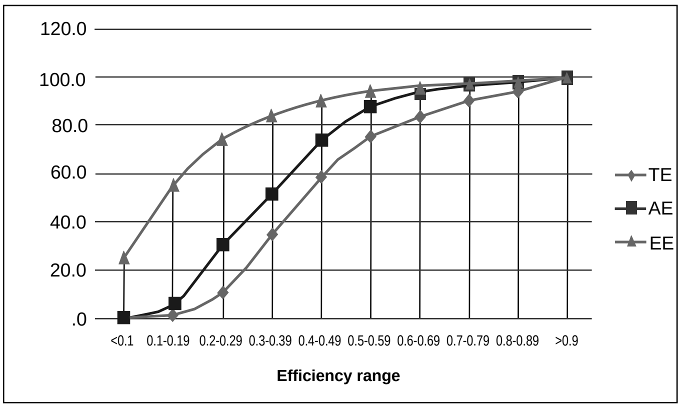
Figure1 : Technical and Allocative Efficiencies



Source: Ajibefun (2008)

Figure 2 represents the cumulative percentages of technical, allocative and economic efficiency. The results show that 76% of technically efficient farmers, 88% of allocatively efficient farmers and 94% of economically efficient farmers are below 60% of efficiency point. This shows that a lot of cotton farmers are in low efficiency levels and few cotton farmers in high efficiency levels.

Figure 2: Cumulative percent for TE, AE and EE



Source: Author's Calculations

Ordinary Least Square Results

According to the results from an OLS regressions model in Table 4, female headed households have a positive and significant impact at 90% confidence interval on technical efficiency but no significance impact on allocative and economic efficiency even though the positive sign is consistent. This means that female headed households in the sample are likely to influence technical efficiency compared to the male

Table 4: Factors explaining technical, allocative and economic efficiency

VARIABLES	Technical Efficiency	Allocative Efficiency	Economic Efficiency
Constant	0.489***	0.395***	0.232***
	(0.0529)	(0.0468)	(0.0511)
Gender (female=1, 0 otherwise)	0.0373*	0.0188	0.0223
	(0.0200)	(0.0178)	(0.0203)
Age of the Household head	0.000417	8.41e-05	0.000338
	(0.000501)	(0.000442)	(0.000502)
No. of Years in Formal School of the Head	0.00382*	0.00175	0.00248
	(0.00203)	(0.00176)	(0.00188)
Number of Prime Age Adults (15 – 59 yrs)	-0.0199***	-0.0104***	-0.0159***
	(0.00490)	(0.00387)	(0.00442)
Area of Cultivated Land	-0.0171***	-0.0188***	-0.0130**
	(0.00552)	(0.00572)	(0.00589)
Number of Weeding	-0.00554	-0.00301	-0.00301
	(0.00772)	(0.00676)	(0.00751)
Dummy: Ridges=1, 0=CF tillage	-0.0107	0.00462	-0.00826
	(0.0307)	(0.0276)	(0.0314)
Dummy: Plough=1, 0=CF tillage	-0.0220	-0.00324	-0.0267
	(0.0312)	(0.0284)	(0.0318)
Dummy: Handhoe=1, 0=CF tillage	0.0276	0.0428	0.0309
	(0.0335)	(0.0295)	(0.0344)
Dummy: Crop residues=1, 0 otherwise	0.0339**	0.0295**	0.0328**
	(0.0144)	(0.0127)	(0.0143)
Dummy: Crop rotation=1, 0 otherwise	-0.0362**	-0.0333**	-0.0382**
	(0.0155)	(0.0142)	(0.0157)
Dummy: Chureza seed=1, 0=F135	0.0292	0.0324*	0.0349*
	(0.0195)	(0.0172)	(0.0192)
Dummy: Ngwezi seed=1, 0=F135	0.0665	0.0703	0.0610
	(0.0496)	(0.0465)	(0.0506)
Dummy: CDT II seed=1, 0=F135	0.0214	0.0170	0.0202
	(0.0327)	(0.0290)	(0.0313)
Dummy: Eastern=1, 0=Central	0.0678***	0.0475*	0.0335
	(0.0251)	(0.0245)	(0.0272)
Dummy: Southern=1, 0=Central	0.0432	0.0100	0.0164
	(0.0306)	(0.0273)	(0.0301)
Value of Production Assets (000,000)	0.00246***	0.00238***	0.00254***
	(0.000802)	(0.000766)	(0.000839)
Value of Net Off farm Income (000,000)	0.00323*	0.00362**	0.00329
	(0.00188)	(0.00179)	(0.00209)
Observations	812	812	812
R-squared	0.149	0.152	0.105

Source: Author's Calculations, (Standard errors in parethese, ***P<0.01, **P<0.05, *P<0.1

headed households. The main reason for this could be that females are likely to be members of farmer groups, attend meeting regularly relative to their male counterparts. In that regard, they become more knowledgeable and able to accept known techniques of cotton production which later improves efficiency. Similar results were obtained from studies done elsewhere [26].

Education of a household head is an important factor in influencing efficiency of a farmer. The regression results show that there was a positive relationship between education of household head and efficiency though the result was only significant at 10% for technical efficiency. The plausible reason is that more educated farmers have better access to extension services, financial institutions and price information in comparison with their less educated counterparts. They could make better technical decisions on one side and help them in allocating their inputs efficiently and effectively on the other side. Studies done in Pakistan, Dominican Republic, Malawi, Nigeria, India and Kenya show similar results [10, 25, 28, 29, 30, 31].

Household size variable is an important variable especially in crops which are labour intensive such as cotton. Since not every household member is important in taking part in agricultural related activities, a number of adult from 15 to 59 years was considered in the model. The results show that the number of adult is negatively correlated with technical, allocative and economic efficiency scores and it is highly significant at 1 percent probability. The result suggests that as the number of prime age adult increases, efficiency of cotton farmers reduces. The plausible reason for this, could be that as the number of prime age adults of the household increases per unit area, diminishing marginal returns set in where the benefits from an additional prime adult member of the household reduces. Similar results were obtained from a study done in Bangladesh where a standard Tobit regression was used[27].

A lot of studies have been done to ascertain the relationship between the farm size and efficiency. Mixed results have been reported where some have shown a negative relationship while others have shown a positive relationship. In this study the variable captures the land cultivated by cotton farmers. Our hypothesis was that as the land cultivated increases, it reduces the efficiency of cotton farmers. The study found a negative relationship between land cultivated and all the three efficiency categories support that hypothesis. The results suggest that large cultivated land may encounter more problems in applying farm inputs such as allocating labour to do farm operations at the right time in specific fields. This results in an inefficient way of using farm inputs. In other words, when a farm is relatively small, a cotton farmer could combine his/her resources better. The results are similar with those found in Haiti, West Java, Nigeria, Malawi, Tunisia, [26, 32, 33, 34, 35].

Crop residues in the field improve moisture retention and in some cases it improves the fertility of the soil as the crop residues rot through improved organic matter content of the field. The regression results show that cotton farmers who were leaving crop remains had a positive correlation with technical, allocative and economic efficiency. The probable reason for this result could be that crop residues improve soil fertility and also enhances water retention.

The variety of seed planted is an important variable in improving productivity among smallholder farmers. In Zambia, there are four cotton varieties planted by farmers and these are *Chureza*, F135, *Ngwezi* and CDT II. Holding F135 constant, it was found that Chureza significantly performed better than F135 in improving allocative and economic efficiency. While other varieties (*Ngwezi* and *CDT II*) showed a positive correlation but the results were not significant.

Productive assets in this study include oxen and farm equipment such as ox-cart, rippers, plough and hand hoes etc. could result in improving production efficiency. Farmers who have animals (oxen) are more likely to finish land preparation earlier than those who do not. This could result in improving farm productivity as well as reducing transaction costs as highlighted from the study done in Zambia[36]. Ownership of productive assets in this study was found to positively influencing technical, allocative and economic efficiency. The main reason for this could be that productive assets enable farmers to do farm activities on time and this could improve technical, allocative and economic efficiency.

Off-farm activities could be a means to raise income and that can assist farmers to do any farm activities. The study done in Zambia highlighted that cash constrained cotton farmers turn to ginning companies to finance cotton production since they are assured of getting the inputs needed for cotton production[13]. However if farmers have some off-farm income, it could help them do farm activities such as land preparations and weeding on time. The regression results show a positive and significant relationship between off-farm income and technical and allocative efficiency as expected.

Tillage system used has a bearing in the efficiency of the farm. It has been argued that conservation farming minimum tillage systems like ripping and plating basins improve the efficiency use of farm inputs such as fertilizer and water use. A study done in Zambia showed that great bulk of the observed gain on the yield under conservation farming stemmed from water harvesting, precision and timeliness of the conservation farming system[37]. This study has found a positive relationship between technical and economic efficiency and conservation minimum tillage systems (planting basins, ripping) though the results were not significant. The main reason for this could be that rainfall during the season 2006/07 was normal in all cotton growing areas with an average amount of over 1000mm. Conservation minimum tillage systems tend to work efficiently during drier years and since this was a normal year in terms of rainfall that might have affected its performance on efficiency.

Finally, a provincial dummy variable was introduced to capture variations in some characteristics such as size of the fields in the provinces. Holding Central Province constant, the results show that Eastern Province had a positive and significant correlation with technical and allocative efficiency. The results of Southern Province were also positively correlated even though the correlation was not significant. The plausible reason why Eastern Province performed relatively better than Central Province is that the farmers had relatively smaller fields (0.81 hectares) than their counterparts in Central province with 1.29 hectares of a field. With smaller fields, cotton farmers in Eastern Province might have combined the resources efficiently

CONCLUSION AND RECOMMENDATIONS

The mean technical, allocative and economic efficiency scores of 46%, 37% and 20% respectively indicate some relative level of inefficiency among cotton farmers of Zambia compared to other studies done in cotton in West Africa and other developing countries. These results indicate that cotton farmers have the potential to reduce physical input use and production cost on average by 54% and 63% respectively without reducing cotton output of farmers but by improving their level of technical and allocative efficiency.

Results from OLS regression show that, female headed households, number of years spent in school, crop residues, planting *Chureza* cotton seed variety holding *F135* cotton seed variety constant, value of productive assets, off-farm income and Eastern Province while holding Central province constant have a positive relationship with efficiency. These factors therefore, are likely to positively influence efficiency among smallholder cotton farmers.

Therefore, the study recommends that cotton stakeholders should devise strategies of involving more women in cotton production, improve access to productive assets, and encourage adoption of conservation farming such as crop residues retention in the field as the means to improve cotton production efficiency.

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REFERENCES

1. Frisvold G. & Ingram K. (1994). Source of Agricultural productivity growth and stagnation in Sub-Saharan Afrocan, Washington DC, USA.
2. Forum for Agricultural Research in Africa (FARA) 2006. *Framework for African Agricultural Productivity / Cadre pour la productivité agricole en Afrique.* Accra, Ghana. 72 pp.
3. Deininger, K. and Olinto, P. 2000. Why Liberalization Alone Has Not Improved Agricultural Productivity in Zambia: The Role of Asset Ownership and Working Capital Constraints. World Bank Policy Research Working Paper No. 2302.

4. Ministry of Finance & National Planning (MoFNP) 2006. Fifth National Development and Planning", Lusaka, Zambia.
5. Farrell M. J (1957), The measurement of Productive Efficiency. Journal of the Royal Statistical Society. Series A (General), Vol. 120, No. 3, (1957), pp 253-290
6. Tschirley, D. and Kabwe, S. 2007. Cotton in Zambia: 2007 Assessment of its Organization, Performance, Current Policy Initiatives, and Challenges for the Future. FSRP Working Paper No. 26. Lusaka, Zambia
7. Brambilla I. & Porto G. G. (2009). Market Structure, Outgrower Contracts and Farm Output. Evidence from Cotton Reforms in Zambia, Lusaka, Zambia.
8. Tschirley, D., Poulton, C., and Lambaste, P. (2009). Organization and Performance of Cotton Sectors in Africa; Learning from Reform Performance. IBRD/The World Bank. D.C. USA.
9. Ngassam S. B., Nzomo J. C., and Neba C. (2010). The Determinants of the Technical Efficiency of Cotton Farmers in Northern Cameroon. University of Dschang.
10. Mohammad I. J. (2009). Efficiency Analysis of Cotton-Wheat and Rice-Wheat Systems in Punjab, Pakistan. Pakistan.
11. Mevlut G., Besir K., Erdal D., Goksel A. M. and Oguz P. (2009). Determination of technical efficiency in cotton growing farms in Turkey: A case study of Cukurova region. Cukurova, Turkey.
12. Shafiq M. and Tahir R. (2000). The extent of resource use inefficiencies in cotton production in Pakistan's Punjab: an application of Data Envelopment Analysis. Agricultural Economics. Vol 22 (2000), pp 321-330.
13. Haggblade S., Kabwe S. and Plerhoples C. 2010. *Productivity Impact of Conservation Farming on Smallholder Cotton Farmers in Zambia*. Working Paper 47. Food Security Research Project (FSRP).
14. Jayne, T. S., and Argwings-Kodhek G. 1997. Consumer response to maize market liberalization in urban Kenya. *Food Policy*, Vol. 22, No. 5, pp. 447-458.
15. Hoff, A., 2007. "Second stage DEA: Comparison of approaches for modelling the DEA score." European Journal of Operational Research Vol. 181, 425-435.
16. McDonald J. 2008. "Using least squares and tobit in second stage DEA efficiency analyses." European Journal of Operational Research Vol. 197, 792-798.
17. Banker, R.D., Natarajan R. 2008. "Evaluating contextual variables affecting productivity using Data Envelopment Analysis." Operations Research Vol. 56, 48-58.
18. Chavas, J., Petrie, R., Roth, M., 2005. Farm household production efficiency: evidence from the Gambia. American Journal of Agricultural Economics 87:160-179.
19. Binam, J.N., Tonyè, J., Wandji, N., Nyambi, G., Akoa, M., 2004. Factors affecting the technical efficiency among smallholder farmers in the slash and burn agriculture zone of Cameroon. Food Policy 29, 531–545.
20. Fletschner, D. K. and Zepeda L. 2002. "Efficiency of small landholders in Eastern Paraguay." *Journal of Agricultural and Resource Economics* 27(2):554 – 572.
21. Ajibefun, I. A. (2008). An evaluation of parametric and non-parametric methods of technical efficiency measurement: application to small scale crop production in Nigeria. J. Agric. Soc. 4: 95-100
22. Rios, A.R. and Shively G.E. (2005). Farm size non parametric efficiency measurements for coffee farms in Vietnam. Proc. America Agricultural Economics Association Annual Meeting. 24-27 July 2005, Providence, Rhode Island.
23. Coelli T., Rao S.P. and Battese G.E. (1998). An Introduction to efficiency and productivity analysis. Kluwer Academic Publishers, Boston.
24. Green H. W. 2003. "Econometrics Analysis, 4th ed." New Jersey: Pearson Education, Inc.
25. Bravo-Ureta E. B. and Pinheiro E. A. (1997). Technical, Economic, and Allocative Efficiency in Peasant Farming: Evidence from the Dominican Republic. The Dev. Econ. 34: 48-67.
26. Dolisca F. and Curtis M. J. (2008). Technical Efficiency of Traditional and Non-Traditional Crop Production: A Case Study from Haiti. World Journal of Agricultural Sciences 4(4): 416-426
27. Islam K.M, Backman S., Sumelius J. (2011) Technical Economic and allocative efficiency of microfinance borrowers and non-borrowers: Evidence from Peasant Farming in Bangladesh.
28. Coelli T. and Battese G.E. 1996. "Identification of factors which influence the technical inefficiency of Indian farmers." Australian Journal of Agricultural Economics, Vol. 40, No 2, pp 103-128
29. Chirwa W. E. 2007. "Sources of Technical Efficiency among Smallholder Maize Farmers in Southern Malawi." AERC, Nairobi
30. Amos T. T. (2007). An Analysis of Productivity and Technical Efficiency of Smallholder Cocoa Farmers in Negeria. J. Soc. Sci., 15(2): 127-133
31. Nyagaka O. D., Obare A. G., Omiti M. J. and Nguyo W. (2010). Technical Efficiency in resource use: Evidence from smallholder Irish Potato Farmers in Nyandarua North District, Kenya. Africa Journal of Agricultural Research Vol 5(11), pp. 1179-1186
32. Brazdik F. (2006). Non-Parametric Analysis of Technical Efficiency: Factors Affecting Efficiency of West Java Rice Farms, Prague, Cech Republic
33. Okoye, B.C., Onyenweaku C.E., and Agwu A.E. 2006. "Technical Efficiency of Smallholder Cocoyam Farmers: Implications for Agricultural Extension Policy." Anambra State, Nigeria
34. Tchale H. 2009. "The efficiency of smallholder agriculture in Malawi." AFJARE Vol 3 No. 2 September 2009.
35. Mahdi N., Sghaier M., Bachta S. M. (2009). Technical efficiency of water use in the irrigated private schemes in Smar watershed, south-eastern Tunisia.
36. Bwalya R. (2007). Transaction Costs and Smallholder Household Access to Maize Markets in Central Province Zambia. Thesis, University of Makerere, Uganda.
37. Haggblade, S., Tembo, G. 2003. Development, diffusion and impact of conservation farming in Zambia. Working Paper No. 8. Lusaka, Zambia: Food Security Research Project.