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TECHNICAL EFFICIENCY OF MAIZE PRODUCING FARMERS IN ARSI NEGELLE, CENTRAL RIFT VALLEY OF ETHIOPIA: STOCHASTIC FRONTIER APPROACH

SUMMARY

The study was aimed at analysing the technical efficiency in maize production of smallholder farmers in central rift valley of Ethiopia. Cross sectional data from 138 maize producer farmers were collected during 2011/12 production season. The estimated results of the Cobb-Douglas frontier model with inefficiency variables shows that the mean technical efficiency of the farmers in the production of maize is 88 percent. This implies that maize producers can reduce current level of input application by 12 percent given the existing technological level. The discrepancy ratio gamma (γ), which measures the relative deviation of output from the frontier level due to inefficiency, was about 72.61 percent. This implies that about 66 percent of the variation in maize production (yield) among the sample respondents was attributed to technical inefficiency effects. The estimated stochastic production frontier (SPF) model also indicates that DAP fertilizer, Area, Labor, seed and oxen are significant determinants of maize production level. The estimated SPF model together with the inefficiency parameters shows that family size, frequency of extension contact, distance to market, access to credit and number of weeding significantly determine the efficiency level of the farmers in maize production in the study area. Hence, emphasis should be given to improve the efficiency level of those less efficient farmers by adopting the practices of relatively efficient farmers in the area so that they can be able to operate at the frontier. Because in the short run extension packages can be designed based on local practices of the best-practiced farms in order to improve the productivity level of farmers producing maize.

Keywords: chickpea Technical Efficiency, Cobb Douglas, Frontier, Maize

INTRODUCTION

Background of the Study

Ethiopian economy is pre dominantly an agrarian economy. However, the agricultural sector in the country is largely small-scale, subsistence oriented and

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heavily dependent on rainfall, which is highly variable spatially and temporally, agriculture contributes about 41% of the country's GDP, employs 83% of total labour force, and contributes 90% of exports (EEA, 2012). Despite its dominance, in 2011 alone Productive Safety Net Program supported 7.4 million people, whereas an additional 4.5 million people were requiring emergency humanitarian assistance (FEWS NET, 2011). WFP (2010) also indicated that there were more than five million people in need of food assistance in the country.

Report from CSA (1989 and 2011) indicated that there was an increase in total food grain production from 58,505.42 tons in 1988/89 to 203.48 million tons in 2010/2011. However, this increment in output could not be attributed to improvement in productivity alone as there was simultaneous increase in the size of cultivated land from 4.99 million ha to 11.82 million ha in the same period. Alemayehu *et al*. (2012) however, argued that future cereal production growth need to come increasingly from yield improvements as there is little suitable land available for the expansion of crop cultivation in the country, especially in the highlands.

Therefore, if farmers are producing to supply the surplus to the market after feeding themselves with reducing land per capita due to population growth, they need to adopt new farming practices and increase their efficiency (Jema, 2008). However, as indicated by Torkamani and Hardaker (1996), cited in Jema (2008), in areas where there is inefficiency, trying to introduce a new technology may not have the anticipated impact if the existing knowledge is not efficient. In addition, in Ethiopia the adoption of modern and intensive agricultural practices such as the use of chemical fertilizer and improved seeds is quite low (Chanyalew *et al*., 2010).

Measuring efficiency level of farmers benefit economies by determining the extent to which it is possible to raise productivity by improving the neglected source of growth (efficiency) with the existing resource base and available technology. However, there is limited number of studies done in this regard in general and most of the studies show a narrow focus in terms of sampling (Tewodros, 2001). In particular, no studies had been conducted in the area of production efficiency of maize production in the study area. The extent, causes and possible remedies of inefficiency of smallholders are not yet given due attention. Thus, this study has tried to measure the technical efficiency of the farmers in study area and identified its main determinants based on a cross sectional data collected from 138 rural households, interviewed in 2012/2013 production year.

Concept of Technical Efficiency

The efficiency of a firm is its ability to produce the greatest amount of output possible from a fixed amount of inputs and an efficient firm is one that given a state of technical know-how, can produce a given quantity of goods by using the least quantity of inputs possible (Raymond, 1981).

Productive efficiency consists of technical and allocative efficiency. Technical efficiency of a producer is a comparison between observed and optimal values of its outputs and inputs. It refers to the ability to avoid wastage either by producing as much output as technology and input usage allow or by using as little input as required by technology and output production. Technical efficiency has, therefore, both an input conserving and output promoting argument. It is assumed that technical efficiency ranges between zero and one, if TE = 1 implies that the firm is producing on its production frontier and is said to be technically efficient. 1 – TE is therefore the largest proportional reduction in input that can be achieved in the production of the output.

According to Farrell and Fieldhouse (1962), allocative efficiency is related to the ability of a firm to choose its input in a cost minimizing way. It involves the selection of an input mix that allocates factors to their highest valued uses and thus introduces the opportunity cost of factor inputs to the measurement of productive efficiency. AE reflects the ability of the firm to use the inputs in optimal proportions given their respective prices and the production technology. It is assumed that, $0 < AE < 1$, Following the same line of reasoning, 1 – AE measures the maximal proportion of cost the technical efficient firm can save by behaving in a cost minimizing way. Technical efficiency and allocative efficiency are then combined to give economic efficiency, which is sometimes referred to as overall efficiency (Coelli *et al*., 1998). It is assumed that $0 < EE < 1$. Therefore EE = 1 implies that it is both technically and allocatively efficient.

Maize production

Maize is the most widely distributed cereal crop in the world. According to WB (2011), in developed countries 70% of maize is destined for feed only, 3% is consumed directly by humans while in Sub-Saharan Africa outside of South Africa, 77% of maize is used as food and only 12% serves as feed. Maize covers 25 million ha in Sub-Saharan Africa, largely by smallholder farmers that produced 38 million tons in 2008, primarily for food. Maize could have also significant role in improving the livelihood of smallholder farmers in Ethiopia, as it is the crop with the largest holders in the country with 7.96 million holders (CSA, 2011). About 95% of Ethiopian farmers rely on less than five ha of land, of whom 55% cultivate less than two ha (Rashid, 2010).

According to CSA (2011), in 2010/11 production year, maize covered 1.96 million ha of land at national level (about 17% of the total area covered by all crops). The total output of maize in the same year at national level was 49.86 million qt that is 24.5% of the total crop production in the same year. The same source indicated that in Oromia region, the total area covered by maize in the production year of 2010/11 was 1.11 million ha and 28.81 million qt of maize have been produced with the productivity of 25.97 qt per ha.. At the same time, there were 205,330 holders producing 2.12 million qt of maize in 74, 705.84 ha of land in West Arsi zone.

Description of the Study Area

Arsi Negelle district is located in west Arsi Zone of Oromia National Regional State at about 226 km from Addis Ababa with area of 1838 km2. Geographically, the district is located from 380 25' E to 380 54' E longitude and 070 09' to 070 42' N latitude. Except for the South-Eastern part, most of the district's elevation is between 1500 and 2300 metres. Arsi Negelle has the highest number of rivers in the zone. The major rift valley lakes of Abijata, Langano and Shalla are also partly in Arsi Negelle the district. The main crops grown in the area include wheat, maize, teff, barley, sorghum, onion and potato. Annual crops accounted for 95% of all croplands in in the district. About 80% of the district is sub-tropical, while 20% belongs to the temperate agro-climatic zone. The temperature of the area ranges from 16oc to 25oc and annual rainfall ranges between 500-1150 mm. The rainfall of the area is a bimodal, with short rain occurring from February to April and the main rain from June to October. The short allow farmers to grow potato early and later replace by small cereals specifically wheat. (Figure 1)

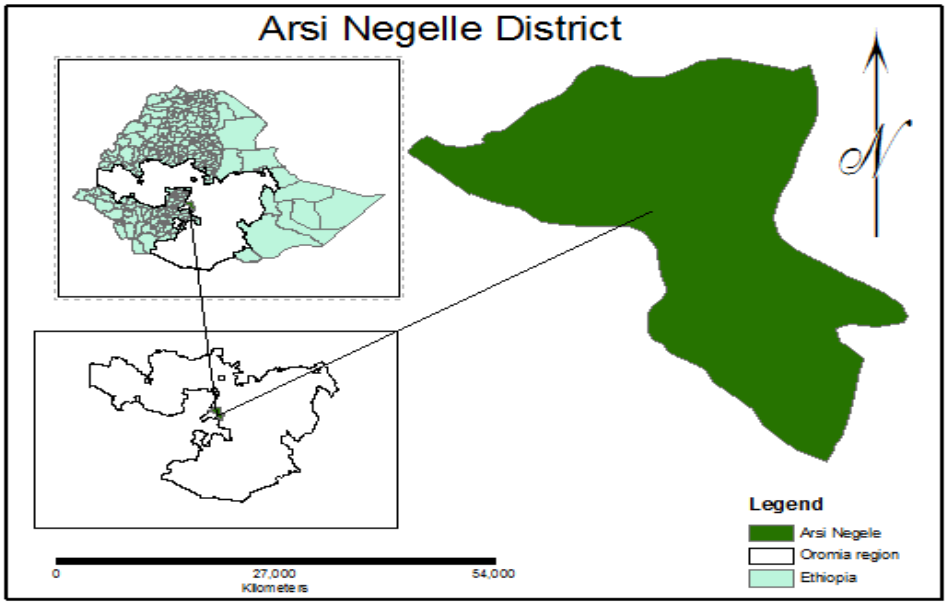

Figure 1 location of the study area

MATERIAL AND METHODS

For its ability to distinguish inefficiency from deviations that are caused from factors beyond the control of farmers, a stochastic frontier approach was applied to estimate the level of technical efficiency of farmers. In general, crop production is likely to be affected by random shocks such as weather, pest infestation and drought. In addition, measurement errors are likely to be high. In such a condition where random shocks and measurement errors are high, a model

that accounts for the effect of noise is more appropriate to choose. Thus, the stochastic efficiency decomposition methodology is chosen as more appropriate for this study. The stochastic frontier production function can be written as:

$$Y_i = F(X_i;\beta)\exp(V_i - U_i) \qquad \text{I = 1, 2, 3,... n (1)}$$

*Where Y_i is the production of the i^{th} farmer, X_i is a vector of inputs used by the i^{th} farmer, β is a vector of unknown parameters, V_i is a random variable which is assumed to be N $(0, \sigma_v{}^2)$ and independent of the U_i which is nonnegative random variable assumed to account for technical inefficiency in production.

Though a study done by Kopp and Smith (1980) suggests that functional specification has only a small impact on measured efficiency, as stochastic frontier method requires a prior specification of the functional form a log likelihood ration test indicated that Cobb-Douglas production function is the best functional form for this study.

A single stage estimation procedure was followed to analysis determinates of TE from a stochastic frontier production function. In single stare estimation, inefficiency effects are defined as an explicit function of certain factors specific to the firm, and all the parameters are estimated in one-step using the maximum likelihood procedure. The major drawback with the two-step approach resides in the fact that, in the first step, inefficiency effects *are* assumed to be independently and identically distributed in order to use the Jondrow *et al*. (1982) approach to predict the values of technical efficiency indicators. In the second step, however, the technical efficiency indicators thus obtained are assumed to depend on a certain number of factors specific to the firm, which implies that the *TE* are not identically distributed unless all the coefficients of the factors considered happen to be simultaneously null.

RESULTS AND DISCUSSION

Econometric Results

The stochastic production frontier was applied using the maximum likelihood estimation procedure. Prior to model estimation, a test was made for multicollinearity among the explanatory variables using the Variance Inflation Factor (VIF) and the values of VIF for all variables entered into the model were below 10, which indicate the absence of multicollinearity among the explanatory variables. In addition, Breusch-Pagan test was also used to detect the presence of hetroskedasticity and the test indicated that there was no problem of hetroskedasticity in the models. The result of the model showed that DAP, area under maize, oxen power, labour and seed had positive and significant effect on the level of output. This means that, the increase in these inputs would increase output of maize (Table 1).

Table 1. Estimates of the Cobb Douglas frontier production function

Variables	Coef.	Std. Err.
DAP	0.053***	0.006
Urea	0.002	0.002
Seed	0.570***	0.063
Land	0.235***	0.071
Labor	0.109**	0.049
Oxen	0.135***	0.045
_cons	5.643***	0.220
Gamma (γ)	0.726***	0.133
Sigma^2 (δ^2)	0.035**	0.012

***, ** and * show significance at 1%, 5% and 10% probability level, respectively; Source: model output

The diagnostic statistics of inefficiency component reveals that sigma squared (δ^2) was statistically significant which indicates goodness of fit, and the correctness of the distributional form assumed for the composite error term. The estimated value of Gamma γ is 0.7261 which indicates that 72.61% of total variation in farm output is due to technical inefficacy.

Efficiency scores

The model output presented in Table 2 indicates that farmers in the study area were relatively good in TE. The mean TE was found to be 88.38%. This means in the short run there are opportunities for reducing maize production inputs by 11.62% by performing the practice of technically efficient farmer in the locality.

Table 2. Summary of descriptive statistics of efficiency measures

Type of efficiency	Minimum	Maximum	Mean	Std. Deviation
TE	.52024	.99891	.88384	.10117

Source: model output

The level of TE at which sample households operate is presented in Table 2. Most of households had a higher technical efficiency levels. About 60% of maize farmers in the study area were operating above the efficiency level of 90% and 22.46% of them were operating in the range of 80-90% of technical efficiency levels. On the other hand, none of the farmers was operating below 50% of technical efficiency level.

After measuring levels of farmers' efficiency and determining the presence of efficiency differences among farmers, finding out factors causing efficiency disparity among farmers was the next most important step of this study. The maximum likelihood estimates showed that among 15 variables used in the

analysis, Family Size, access to credit, Number of weeding, frequency of extension contact and distance to market were found to be statistically significant to affect the level of TE of farmers (Table 3).

Table 3. Maximum likelihood estimates of inefficiency variables

Variables	Coefficient	Std. Err
Age^2	-0.000178	0.000381
Education	-0.100683	0.182513
Family size	0.2345745*	0.131515
Experience	0.0324539	0.03844
Cultivated land	0.0130075	0.243787
Livestock (TLU)	-0.020109	0.027383
Extension	-0.045759***	0.015279
Training	0.1667838	0.46368
Credit	-1.664235***	0.498376
Farm to home distance	-0.309003	0.202848
Number of weeding	-0.764679*	0.419051
Home to marker distance	0.2472861**	0.124179
Soil fertility	-0.429503	0.451856
Off/non-farm activity	-0.199926	0.525096
Crop rotation	-0.267038	0.405898
Cons	-0.630863	1.347534
Sigma_v	0.0984114	0.012476

***,** and * represents significant levels at 1%, 5% and 10% respectively
Source: model output

Frequency of extension contact had statistically significant positive relationship with technical efficiency. Which indicates households who receive more extension visits by extension workers appear to be more technically efficient than their counterparts. This result is also similar to those obtained by Jude *et al.* (2011) and Mbanasor *et al.* (2008).

The results also indicated that access to credit had a positive and statistically significant effect on technical efficiency. Credit availability shifts the cash constraint outwards and enables farmers to make timely purchases of those inputs that they cannot provide from their own sources. This result is in line with the arguments of Amadou (2007), Nyagaka1 *et al.* (2009) and Jude *et al.* (2011).

Distance from home to the nearest market was also significant in determining technical efficiency. This might be due to the fact that as farmers are

located far from market, there would be limited access to input and output markets and market information. Moreover, higher distance to market leads to higher transaction cost that reduces the benefits that accrue to the farmer. More importantly, longer distance from market discourages farmers from participating in market-oriented production. Similar result was found in the work of Alemu *et al. (*2008).

Family size also found to have negative and significant relation with technical efficiency. This may be due to the reason that household with large number family members may not be able to use appropriate input combinations due to shortage of cash. This result is also similar to those obtained by Ayodele *et al.* (2008).

Number of weeding was also among the significant variables in determining TE of farmers in the study area. The result indicated that weeding improves the level of technical efficiency of maize growing farmers of the study area. Hence, there is a possibility to increase the yield of maize through advising farmers to protect their maize field from any kind of weed without searching for any other external inputs. Similar result was found in the work of Haileselassie (2005).

CONCLUSIONS

Thus, the results of the study give information to policy makers and extension workers on how to better aim efforts to improve farm productivity as efficiency level and determinant for technical efficiency are identified. The result of the analysis showed that maize producers in the study area are not operating at full technical efficiency level which indicates the existence of opportunity for maize producers to minimize cost without compromising yield with present technologies available at the hand of producers. Therefore, an intervention aiming to improve efficiency of farmers in the study area.

The study also revealed that distance to market has a significant influence on the technical efficiency of smallholders. Therefore, farmers have to get inputs easily and communication channels has to be improved to get better level of technical efficiency.

The result indicated that extension contact has positive and significant contribution to technical efficiency. Therefore, appropriate and adequate extension services should be provided. This could done by designing appropriate capacity building program to train additional development agents and to provide refreshment training for development agents.

Access to credit has a positive influence on technical efficiency. Therefore, better credit facility has to be produced via the establishment of adequate rural finance institutions and strengthening of the available micro-finance institutions and agricultural cooperatives to assist farmers in terms of financial support through credit are crucial to improve farm productivity.

The result also identified that number of weeding is positively related to technical efficiency. This calls for any concerned development stakeholders in

the area of crop production to come up with effective strategies on weed controlling mechanisms.

Family size is contributing negatively to technical efficiency in the study area. Thus, concerned bodies have to reduce the dependency through creation of job opportunity by introducing possible investment opportunity (labour intensive) and family planning programs should be strengthened to reduce the average family size to create proportional change between economy of household and its family size in the long-run.

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TEHNIČKA EFIKASNOST PROIZVOĐAČA KUKURUZA U ARSI NEGELLE, NIZIJI U CENTRALNOJ ETIOPIJI: STOHASTIČKI GRANIČNI PRISTUP

SAŽETAK

Cilj studije je analiza tehničke efikasnosti malih farmera u proizvodnji kukuruza u niziji centralne Etiopije. Podaci kojima je obuhvaćemo više sektora i 138 poljoprivrednih proizvođača kukuruza prikupljeni su tokom sezone 2011/12. Rezultati dobijeni primjenom Cobb-Douglas graničnog modela sa varijablama neefikasnosti, pokazuju da je prosječna tehnička efikasnost poljoprivrednika u proizvodnji kukuruza 88 odsto. To znači da proizvođači kukuruza mogu smanjiti sadašnji nivo primjene za 12 odsto, s obziron na postojeći tehnološki nivo. Odnos neusklađenosti gama (γ), koji mjeri relativno odstupanje rezultata od graničnog nivoa zbog neefikasnosti, bio oko 72,61 odsto. To znači da se oko 66 odsto varijacija u proizvodnji kukuruza (prinosu) među ispitanicima iz uzorka može pripisati efektima tehničke neefikasnosti. Proračun dobijen primjenom modela stohastičke granične proizvodnje (SPF) takođe ukazuje na to da DAP đubrivo, regija, rad, sjeme i goveda predstavljaju značajne determinante nivoa proizvodnje kukuruza. SPF model zajedno sa parametrima neefikasnosti pokazuje da veličina porodice, učestalost kontakta, udaljenost tržišta, pristup kreditima i količina korova značajno određuju nivo efikasnosti poljoprivrednika u proizvodnji kukuruza u ispitivanoj oblasti. Dakle, potrebno je unaprijediti nivo efikasnosti manje efikasnih poljoprivrednika usvajanjem prakse relativno efikasnih poljoprivrednika u oblasti, tako da i oni mogu da rade na granici. Jer, u kratkom roku se mogu donijeti mjere proširenja na osnovu najbolje prakse koja se primjenjuje na farmama u cilju poboljšanja nivoa produktivnosti poljoprivrednika u proizvodnji kukuruza..

Ključne riječi: tehnička efikasnost, Cobb Daglas, granica, kukuruz