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Original Article

Technical Efficiency of Smallholder *Teff* Producing Farmers in Ethiopia

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ABSTRACT

A large majority of Ethiopians and the poor live in rural areas are deriving their livelihood from agriculture. The major grain crops grown in Ethiopia are teff, wheat, maize, barley, sorghum, and millet. Teff has remained an important crop to Ethiopian farmers for several reasons, namely: the price for its grain and straw are higher than other major cereals; the crop performs better than other cereals under moisture stress and waterlogged conditions; its grain can be stored for a long period of time without being attacked by weevils. The primary objective of this seminar was to review determinants and level of technical efficiency of teff production system in Ethiopia. This was achieved by reviewing the efficiency of smallholder teff farmers and identifying the determinants of technical efficiency. The review showed that DEA and SPF models are used to estimate level of technical efficiency and identify determinants of technical efficiency, and technical efficiency is significantly affected by Income level, improved seed, education level, livestock holding, extension contact, training, participation in irrigation, labor availability, fertilizer, participation in soil and water conservation, off/non-farm occupation, sex of the household, fertility status of land, credit availability, man day, oxen day, pesticides, herbicides, access to input and output market, number of weeding, family size, group membership, Households` expenditure, farm size, participation in share cropping, social status, age of the household, slop of the farm, number of crops cultivated by the households and land fragmentation. Moreover, the level of technical efficiency of teff production in

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Ethiopia falls on between 55% and 90% indicating a good potential for increasing teff output by 10%-45% with the existing technology and levels of inputs.
Keywords: Technical efficiency, Teff production, Ethiopia

INTRODUCTION

Background

A large majority of Ethiopians and the poor live in rural areas are deriving their livelihood from agriculture. The proportion of the population of Ethiopia residing in rural areas in 2040 is predicted to be nearly 70 percent, when there will be 40 percent more rural residents (UN, 2014). Agriculture in Ethiopia is dominated by smallholder farming households, which cultivated 94 percent of the national cropped area in 2013/14 (CSA, 2014a). The major grain crops grown in Ethiopia are *teff*, wheat, maize, barley, sorghum, and millet. Out of the total grain production, cereals account for roughly 60% of rural employment and 80% of total cultivated land (Abu and Quintin, 2013). In the crop production sub-sector, cereals were the dominant food grains. The major crops occupy over 8 million hectares of land with an estimated annual production of about 12 million tons. The potential to increase productivity of these crops is very high as it has been demonstrated and realized by recent extension activities in different parts of the country. However, population expansion, current low productivity due to lack of technology transfer and decreasing availability of arable land are the major contributors to the current food shortage in Ethiopia (Hailemaryam, 2015). According to CSA (2015) Ethiopian population will exceed 126 million by the year 2030. This increase in population will impose additional stress on the already depleted resources of land, water, food and energy.

According to Alemu *et al.*, (2018) the *teff* crop is the second most widely produced and consumed cereal in Ethiopia. *Teff* has remained an important crop to Ethiopian farmers for several reasons, namely: the price for its grain and straw are higher than other major cereals; the crop performs better than other cereals under moisture stress and waterlogged conditions; its grain can be stored for a long period of time without being attacked by weevils. Real *teff* output on average accounted for 6.1 percent of the real GDP, while growth in real *teff* output accounted for 6.4 percent of the total growth in real GDP (or 0.67 percent of the 10.7 percent growth in real GDP). The evidence indicates that part of the growth in *teff* output has been driven by increases in cultivated area, which averaged 4 percent during the same period (Dorosh *et al.*, 2015). *Teff* accounted for about a fifth of the nationwide agricultural area and was cultivated by nearly half of smallholder farmers during the 2004/05-2013/14 period (CSA 2005a-2014a). It is the most commercialized cereal crop in Ethiopia (Bachewe and Taffesse, 2015). Various staple crops dominate different parts of Ethiopia; however, *teff* is either the principal staple or among the most consumed crops in almost all parts of the country. Moreover, the demand for *teff* is elastic with respect to

income. The share of spending on *teff* in food expenditure is highest in urban areas and increased by 3.4 percent nationwide between 2005 and 2010, during which time real income increased considerably and the share of all other cereals declined (Worku *et al,* 2014). As it is one of the most popular cereals in Ethiopia, it has been historically neglected compared with other staple crops. Furthermore, approximately 6 million households grow *teff* and it is the dominant cereal crop in over 30 of the 83 high-potential agricultural districts. In terms of production, *teff* is the dominant cereal by area planted and second only to maize in production and consumption. However, yields are relatively low (around 1.4 ton/ha.) and high loss rates (25-30% both before and after harvest) reduce the quantity of grain available to consumers by up to 50% (CSA, 2014).

Objectives of the seminar

The general objective of the seminar is to review the technical efficiency of *teff* producing farmers in Ethiopia.

The specific objectives of the seminar are;

1. To explain the different efficiency measurement methodologies used to identifying technical efficiency factors,
2. To review the level of technical efficiency of *teff* production in Ethiopia,
3. To review the determinants of technical efficiency of *teff* production in Ethiopia.

TECHNICAL EFFICIENCY OF *TEFF* PRODUCING FARMERS

Concepts and Definitions of Technical Efficiency

Farrell (1957) defined efficiency as the ability of farm's production to attain optimum level of output from a given bundle of input. Many scholars used productivity and efficiency interchangeably and consider both as the measure of performance of a given firm. However, these two interrelated terms are not precisely the same things (Coelli, 1995). In simple term, production frontier defines the current state of technology in an industry, firms in that industry would presently be operating either on that frontier, if they are perfectly efficient or beneath the frontier if they are not fully efficient.

On the other hand, productivity improvements can be achieved in two ways. Once can either improve the state of the technology by inventing new ploughs, pesticides, rotation plans, etc. this is commonly referred to as technological change and can be represented by an upward shift in the production frontier. Alternatively one can implement procedures, such as improved farmer education, to ensure farmers use of the existing technology more efficiently.

This would be represented by the firms operating more closely to the existing frontier. It is thus evident that productivity growth may be achieved through either technological progress or efficiency improvement, and that the policies required to address these two issues are likely to be quite different. Production technology is commonly modeled by means of production function, which in the scalar output case specifies the maximum output obtainable from an input vector. The degree to which the actual output of a production unit approaches its maximum is the technical efficiency of production. Productivity is the quantity of a given output of a firm per unit of input. Technical efficiency (that part of efficiency which explains the physical performance of a firm) measures the relative ability of a firm to get the maximum possible output at given input or set of inputs. Technically efficient firms are those firms that are operating on the production frontier that represents the maximum output attainable from each input level (Coelli, 1995). The concept of efficiency is considered with the relative performance of processes used in transforming given inputs into output. Farrell (1957) identified at least two types of efficiency. These are technical and allocative efficiencies. Technical and allocative efficiency (price efficiency) in production, which together comprises the economic efficiency are through the use of frontier production function. While technical efficiency relates the physical input with the optimum level of output that can be produced at a given level of technology, Allocative efficiency reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices and the production technology. Economic efficiency is the multiplicative product of technical and allocative efficiencies.

The simple and straight forward way of measuring efficiency of a farm could be yield per hectare. However, given output is a function of multiple inputs in the reality, this is very simplistic way of measurement in that it only considers a single input of production, land. The other technique is to use the conventional econometric analysis, which generally assumes that all producers always manage to optimize their production process. However, there are discrepancies between production amount and production values even if the enterprises have identical technological constraints. This depends upon different productive capabilities and less favorable utilization resources by some enterprises (Burhan, Ceylan, and Hatice, 2009).

The traditional, least squares-based, regression techniques attribute all departures from the optimum exclusively to random statistical noise. However, producers do not always succeed in optimizing their production. Therefore, it is desirable to recast the analysis of production away from the traditional functions towards frontiers (Kumbhakar and Lovell, 2000). Thus production frontier characterizes the minimum input bundles required to produce a given level of output or the maximum possible level of production of output from a given level of inputs, commonly called technical efficiency. Even though there is some similarity between terms production efficiency

and technical efficiency, however, they are not same. The simplest way to differentiate production and technical efficiency is to think of productive efficiency in terms of cost minimization by adjusting the mix of inputs, whereas TE is output maximization from a given mix of inputs (Palmer and Torgerson, 1999).

According to Coelli (1995) in analyzing efficiency, fitting a frontier model performs better than Ordinary Least Square (OLS) regression. The two main benefits of estimating the frontier function, rather than average (e.g. OLS) functions, are that:

i. Estimation of an average function will provide a picture on the shape of technology of an average firm, while the estimation of the frontier function will be most heavily influenced by the best performing firm and hence reflect the technology they are using.
ii. The frontier function represents a best practice technology against which the efficiency of firms within the industry can be measured. It is this second use of frontiers, which leads to widely application of estimating frontier functions.

Approaches of efficiency measurement

Basically there are two approaches in measuring efficiency: input oriented and output oriented. The output oriented approach deals with the question "by how much output could be expanded from a given level of inputs?" Alternatively one could ask "by how much can input of quantities be proportionally reduced without changing the output quantity produced?" This is an input oriented measure of efficiency. However, both measures will coincide when the technology exhibits constant returns to scale, but are likely to vary otherwise (Coelli andBattese, 2005).

Input-oriented efficiency measures

The concept of input-oriented measures of efficiency of a firm which uses two inputs x_1 and x_2 to produce a single output y, under the assumption of constant return to scale can be illustrated in Figure1. Two inputs x_1 and x_2 are represented on horizontal and vertical axes respectively. EE* represents an iso-quant of a fully efficient firm. All points on this iso-quant represent technically efficient production. Assume a firm is producing at point A as shown in Figure 1; this firm produces the same level of output as is produced by the fully efficient firm. To define the technical efficiency (TE) of this firm, a line is drawn from the origin to the point A. This line crosses the iso-quant at the point C. In the case of a fully efficient firm, y* amount of output (y) is produced using inputs (x_1 and x_2) at point C whereas in case of the observed firm, operating at A, additional inputs are used to produce y* amount of output (y). Therefore, observed firm, operating at A, does not use inputs efficiently. The technical efficiency of the

observed firm can be defined as the ratio of the distance from the point C to the origin over the distance of the point A from the origin:

$$TE = \frac{OC}{OA} \quad (1)$$

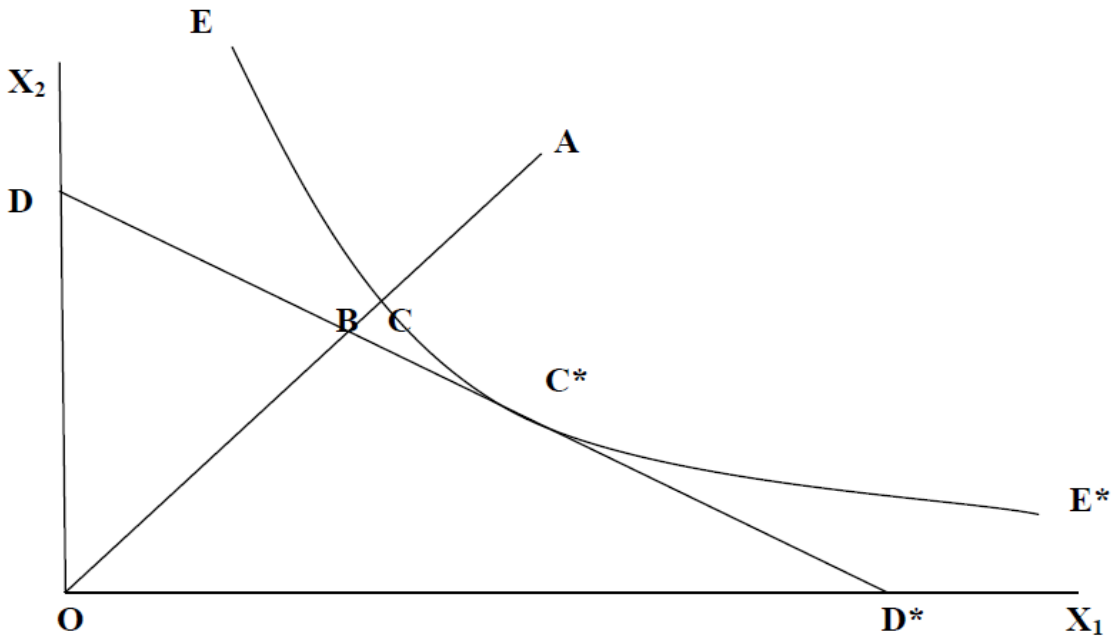

Figure 1: Input-oriented measures for technical, allocative and economic efficiencies
Source: Reproduced from Coelli *et al.*, (1998).

The distance CA represents the technical inefficiency of the observed firm, which is the amount by which all inputs could be proportionally reduced without reduction in output. The value of TE lies between 0 and 1. A firm is technically efficient if it has TE equal to 1. If the value of TE is less than 1, the firm is technically inefficient. If input prices are given, allocative efficiency (AE) can also be calculated. A line DD* is drawn tangent to the iso-quant EE* at the point C*. The line DD* represents an iso-cost line showing all possible quantities of the two inputs, given their relative market prices that would cost the same amount to the firm. Slope of the iso-cost line represents the input price ratio. For output quantity produced at point C, the best use of inputs is at point C*, because it represents the minimum cost. The allocative efficiency of the firm is defined as:

$$AE = \frac{OB}{OC} \quad (2)$$

At point C* a farm is both technically and allocatively efficient. Distance BC represents the reduction in production cost that would occur if production were to occur at allocatively and technically efficient point C*, instead of at technically efficient but allocatively inefficient point C. Value of allocative efficiency lies

between 0 and 1. A value of 1 indicates that the firm is allocatively fully efficient while value less than 1 indicates that the firm is allocatively inefficient.

The economic efficiency (EE) is defined as the product of technical and allocative efficiency.

EE = TE x AE

(3)

$$EE = \frac{OC}{OA} \times \frac{OB}{OC}$$

(4)

$$EE = \frac{OB}{OA}$$

(5)

Value of economic efficiency is bounded between 0 and 1. Value of 1 indicates that the firm is economically fully efficient while value less than 1 indicates that the firm is economically inefficient.

Output-oriented efficiency measures

The output oriented measures of efficiency focuses on the changes in output of a firm that may be achieved when using the same quantity of inputs. The concept of output-oriented

Measures of efficiency of a firm producing two outputs (y_1 and y_2) with one input can be illustrated using Figure 2. Two outputs y_1 and y_2 are represented on horizontal and vertical axes respectively. AA* is a production possibility curve showing different combinations of two outputs (y_1 and y_2) produced using a given level of input (x_1). AA* production possibility curve represents a technically efficient practice. Any firm that is producing at this curve is said to be a technical efficient firm. A firm that is producing at point B is technically inefficient firm because it lies below the production possibility curve AA* that represents the upper bound of production possibilities. To define the technical efficiency of the observed firm producing at point B, a line is drawn from the origin to the point B. This line crosses the production possibility curve at point C. The observed firm uses the same input level as is used by the fully efficient firm, operating at point C. The technical efficiency of the observed firm is defined by the ratio of the distance of the point B to the origin over the distance from the point C to the origin. $TE = OB/OC$ The distance BC represents the level of technical inefficiency. It is the amount by which outputs could be increased without requiring extra inputs.

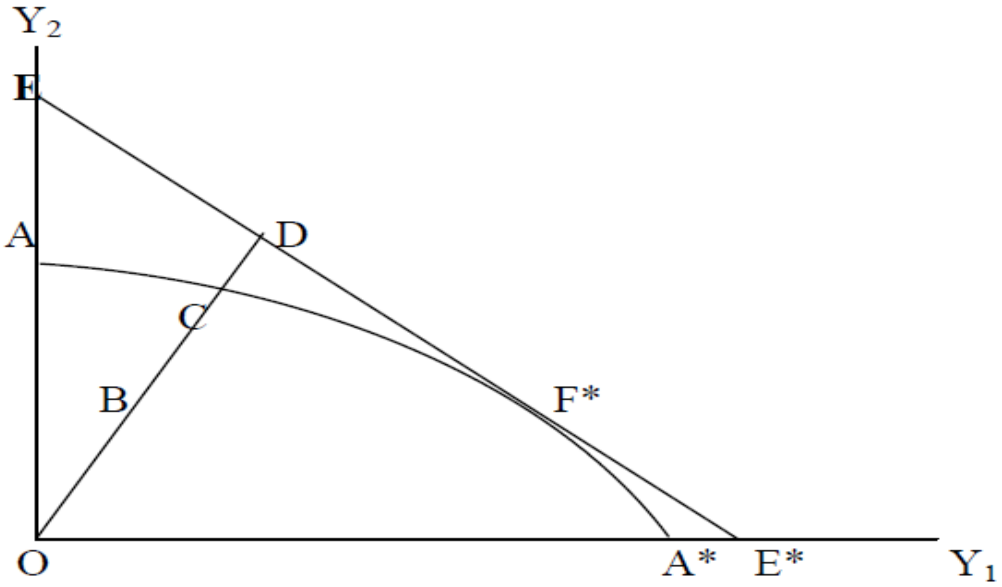

Figure 2: Output-oriented measures for technical, allocative and economic efficiencies
Source: Reproduced from Coelli *et al.*, (1998)

If there is price information it is possible to calculate allocative efficiency. Line EE* represents an iso-revenue curve which is drawn tangent to the production possibility curve at F*. The line OB meets it at point D. The allocative efficiency of the observed firm is defined by the ratio of the distance of point C to the origin over the distance of point D to the origin.

$$AE = \frac{OC}{OD} \quad (6)$$

The economic efficiency of the observed firm is defined as:

$$EE = \frac{OB}{OC} \times \frac{OC}{OD} \quad (7)$$

$$EE = \frac{OB}{OD} \quad (8)$$

Models of Efficiency Measurement

Agriculture is a key in economic development in developing counties. The adoption of new technologies designed to improve farm output and then increase farmer income. The measurement of technical inefficiency in the agricultural sector of developing and developed counties has received attention since the late eighties from an increasing number of researchers, as the frontier approaches to efficiency measurement have become more popular. The production frontier approach to technical inefficiency measurement makes it possible to distinguish between shifts in technology from movements towards the best-practice frontier. By estimating the best practice production function (an unobservable function) this approach calculates technical efficiency as the distance between the frontier and the observed output. Two different

groups of technique have been used to measure technical efficiency under the frontier approach, which differ in the assumptions imposed on the data; non-parametric linear programming technique (Data Envelopment Analysis, DEA), and the Parametric Stochastic Frontier Approach (SFA).

2.1.1. Non-parametric frontier model

The non-parametric approach has been traditionally assimilated into Data Envelopment Analysis (DEA); a mathematical programming model applied to observed data that provides a way for the construction of production frontiers as well as for the calculus of efficiency scores relatives to those constructed frontiers. Data Envelopment Analysis (DEA) is a non-parametric method and can easily handle multiple input and output. Moreover, in DEA, application inputs and output can have very different units of measurement without requiring any a priori trade off or any input and output prices. An input oriented BCC/ Banker- charnes-cooper model/ suggested an extension of the CRS DEA model and the model is given below for N decision making unit (DMU), each producing M outputs by using K different inputs (Coelli *et al.*, 1998).

Min $_{\varphi}$ λ Φ

(9)

Subject to

$-y_i + Y\lambda \geq 0$

$\Phi x_i - X\lambda \geq 0$

$NI\lambda = 1, \lambda \geq 0$

Where Φ is a scalar, NI is convexity constraint and λ is N x 1 vector of constants. Y represents output matrix and X represents the input matrix. The value of Φ will be the efficiency score for the i^{th} firm. This linear programming problem must be solved N times, once for each firm in the sample. A Φ value of 1 indicates that the firm is technically efficient according to the Farrell (1957) definition.

DEA does not impose any assumptions about functional form; hence it is less prone to misspecification. Further, DEA does not take it in to account random error. It is not subject to the problems of assuming on underlying distribution about the error term. However, since DEA cannot take account of such statistical noise, the efficiency estimates may be biased if the production process is largely characterized by stochastic elements but this technique is not the matter of this study.

Parametric frontier models

With respect to parametric approaches, these can be subdivided into deterministic and stochastic models. The first are also termed ‘full frontier’ models. They envelope all

the observations, identifying the distance between the observed production and the maximum production, defined by the frontier and the available technology, as technical inefficiency. The deterministic model assumes that any deviation from the frontier is due to inefficiency, while the stochastic approach allows for statistical noise. A further classification of frontier models can be made according to the tools used to solve them, namely the distinction between mathematical programming and econometric approaches. The deterministic frontier functions can be solved either by using mathematical programming or by means of econometric techniques. The stochastic specifications are estimated by means of econometric techniques only.

Coelli *et al.*, (1998) recommended that SPF is more appropriate than DEA and deterministic models in agricultural applications, especially in developing countries, where the data are heavily influenced by measurement errors, and the effect of weather, disease, etc plays a significant role.

Deterministic models

The parametric deterministic models used for measuring technical efficiency. We assume that production can be modeled as;

$y_i = \alpha + \beta' x_i - u_i$

(10)

Where $u_i \geq 0$ represents inefficiency and all variables are specified in logarithms. In this case,

$DF_i = \exp(-u_i)$

(11)

It is the Debreu-Farrell measure of technical efficiency. It is not necessary to restrict the production function to Cobb-Douglas. This functional form is chosen to be consistent with Aigner and Chu (1968) for convenience. Alternatively, the flexible Trans log production function, which is linear in the parameters, can be specified. This technique is considered deterministic because the stochastic component is completely generated by inefficiency and measurement error is assumed away. Following Greene (1980) the deterministic model can be estimated using OLS. In this case, the slope parameters are estimated consistently, but the intercept is biased. Greene shows that a consistent estimate of a can be obtained by shifting the OLS line upward so that the largest adjusted residual is zero. If the true error term is composed of a normally distributed noise term and a non-negatively distributed inefficiency term, then OLS is not maximum likelihood but still produces unbiased and consistent estimates of the slope parameters. Hence, there will be minor differences between the estimated slope parameters from the stochastic frontier and OLS regressions. Correcting the intercept from an OLS regression is only one deterministic approach. Aligner and Chu (1968) developed linear and quadratic programming alternatives. The deterministic

specification, therefore, assumes that all deviations from the efficient frontier are under the control of some circumstances out of the agent's control that can also determine the suboptimal performance of units. Regulatory-competitive environments, weather, luck, socio-economic and demographic factors, uncertainty, *etc.,* should not properly be considered as technical efficiency. The deterministic approach does so, however. Moreover, any specification problem is also considered as inefficiency from the point of view of deterministic techniques. On the contrary, stochastic frontier procedures model both specification failures and uncontrollable factors independently of the technical inefficiency component by introducing a double-sided random error into the specification of the frontier model.

Stochastic frontier model

The stochastic frontier approach which was introduced by Meeusen and van den Broeck (1977) and Aigner *et al.*, (1977), reversed the conventional belief that deviations from the production frontier are due to inefficiency of the producing units (i.e., factors under the control of the producers, which may not be true). Hence, stochastic estimations of technical efficiency incorporate a measure of random error, which is one component of the composed error term of a stochastic production frontier. This model acknowledges the fact that factors, which are outside the farmers‟ control, can also affect the level of output. So it made possible to find out whether the deviations in production from the frontier output is due to firm specific factors or due to external random factors.

The primary advantage of the stochastic frontier production function is that it enables one to estimate farm specific technical efficiencies. The measure of technical efficiency is equivalent to the production of the i^{th} farm to the corresponding production value if the farm effect u_i were zero. However, the estimation of efficiency using stochastic method requires a prior specification of functional form and needs distributional assumptions (half-normal, gamma, truncated, etc.) for the estimation of U_i, which cannot be justified given the present state of knowledge (Coelli, *et al*, 1998). The stochastic frontier production model incorporates a composed error structure with a two-sided symmetric term and a one-sided component. The one-sided component reflects inefficiency, while the two-sided error captures the random effects outside the control of the production unit including measurement errors and other statistical noise typical of empirical relationships. Hence, stochastic frontier models address the noise problem that characterized early deterministic frontiers. Stochastic frontiers also make it possible to estimate standard errors and to test hypotheses, which were problematic with deterministic frontiers because of their violation of certain maximum likelihood (ML) regularity conditions (Schmidt, 1976).

In stochastic frontier method, technical efficiency is measured by estimating a production function. Different production functions such as Cobb-Douglas, Trans-log, Transcendental, and Quadratic etc. can be used to estimate the frontier. The Trans-log and Cobb-Douglas specifications are commonly used functional forms to estimate the frontier; but both have their merits and demerits. Therefore, the method avoids the imposition of unwarranted structures on both the frontier technology and the inefficiency component that might create distortion in the measurement of efficiency (Shafiq and Rehman, 2000). The choice is made on the basis of the variability of agricultural production, which is attributable to climatic hazards, and insect pests; Moreover, all information gathered on production is usually inaccurate since small farmers do not have updated data on their farm operations.

Level and determinants of Technical Efficiency in Ethiopia

In Ethiopia, a number of researches are conducted on efficiency of farmers in different regions using different models and different variables in order to measure and identify the level and sources of technical efficiency or inefficiency respectively.

Solomon (2012) measured the level of technical, allocative and economic efficiencies of wheat seed production and identified factors affecting them in Womberma Woreda of West Gojjam zone, Amhara National Regional State. Stochastic production frontier model was used to estimate technical, allocative and economic efficiency levels, whereas Tobit model was used to identify factors affecting efficiency levels. His results indicated that mean of TE, AE and EE of sample households were 79.9%, 47.7% and 37.3%, respectively. His result also showed that interest in wheat seed business and total income positively and significantly affects TE while total expenditure has a negative and significant effect. Education level and livestock ownership have a significant positive impact on AE and EE while participation in share cropping and total cultivated land have a significant negative effect on allocative and economic efficiencies, respectively.

Endrias *et al.*, *(*2013) by applying DEA model that the average technical efficiency of maize production in Wolaita and Gamo Gofa Zones of Southern Nations, Nationalities and Peoples Region of Ethiopia was found to be about 0.40. This investigates that if the average farmer in the sample was to achieve the technical efficiency level of its most efficient counter-part, then the average farmer could realize 60 percent cost savings. This indicates that there was a substantial amount of technical inefficiency in maize production. However, about 7.26 percent of the DMUs operated at greater than 90 percent technical efficiency level in maize production and they also investigated by applying tobit model to show that farm size, use of hybrid maize variety, agro-ecology, oxen holding and consumption expenditure of households were highly significant in affecting the technical efficiency of smallholder maize producers.

Beyan *et al.*, (2013) evaluated the technical efficiency of farm production of smallholder farmers in Girawa district. Cobb-Douglas production function was fitted using stochastic production frontier approach to estimate technical efficiency levels and to identify factors affecting efficiency levels of the sample farmers. His result showed that the mean technical efficiency of 81.5%. The discrepancy ratio (γ), which measures the relative deviation of output from the frontier level due to inefficiency, implied that about 75% of the variation in maize production was attributed to technical inefficiency effects. He also found that education, livestock holding, extension contact, farmer's training, cultivated area and participation to irrigation were found to determine technical efficiencies of farmers positively while social status had negative relationship with technical efficiency.

Dawit et al., (2013) estimate a distance function of grain production using generalized method of moments that enabled them to accommodate multiple outputs of farmers as well as address the endogeneity issues that are related with the use of distance functions for multi-output production. They used a panel data set of Ethiopian subsistence farmers, and found that the most important factors determining farmers' efficiency in Ethiopia are having access to the public extension system, participation in off-farm activities, participation in labor sharing arrangements, gender of the household head, and the extent to which farmers are forced to produce on marginal and steeply sloped plots. According to their study, farmers in Ethiopia are producing less than 60 percent of the most efficient farmers, on average. Moreover, the annual technical change between 1999 and 2004 is about one percent while annual efficiency change during the same period is insignificant.

Wondimu and Hassen (2014) The Stochastic Production Frontier (SPF) was employed to determine technical efficiency in maize production of smallholder farmers in Dhidhessa district. From their result, the estimated gamma parameters indicated that 73% of the total variation in maize output was due to technical inefficiency. The average technical efficiency was 86% while return to scale (RTS) was 0.96 %. Based on the results, it was concluded that there existed scope for increasing maize output by 14 percent through efficient use of existing resources. Their result also indicated that area allocated under maize and chemical fertilizers appeared to be significantly influencing maize production at 1 percent probability level and The marginal effect of inefficiency variables such as age, improved seed, labor availability, training were affect positively and significant. On the other hand number of livestock, market distance, and interaction of education and off farm income were affect negative and significant. Tefera *et al.*, (2014) used the Cobb Douglas stochastic production frontier to analyze the technical efficiency in *teff* production in the Raya Alamata district. From his result Fertilizer application rate has contributed positively and significantly to *teff* production, indicating that there is a possibility to increase *teff* production by increasing fertilizer application rate. Education of the household has significant

positive contribution to *teff* production indicating that there is scope for increasing *teff* production by improvement the education level of the farmers. The inefficiency in *teff* production was due to sowing of poor quality seed year after year and large operational farm size.

Solomon (2014) used the SPF model together with the inefficiency parameters to identify factors affecting level of technical efficiency and the study shown that age of the household head measured in years was found to be the determinant of technical inefficiency negatively and significantly. Alternatively, age has a positive and significant effect on TE of *teff* production. The inefficiency effect analysis for major crop production shown that education, participation in soil and water conservation activities, poverty status and adoption of improved seed are the major determinants. Off-farm income of the household head was found to affect technical inefficiency in *Teff* production positively, contrary to this age of household head, slop and TLU were found to affect negatively.

Awol (2014) used SPF to Analysis Economic efficiency of rain-fed wheat producing farmers in north eastern Ethiopia: the case of Albuko district**.** His result indicated that the mean indices of allocative and economic efficiency varying widely, with an average of 42.7% and 31.65%. The study found that sex of the household heads, land fragmentation, fertility status of land, slope, credit use, and training obtained and oxen numbers contributed significantly and positively to TE, while it has inverse related with farm size. The allocative and economic efficiency of the farm household was positively and significantly affected by sex of the household heads, frequency of extension use, oxen number, family size, distance of wheat crop from residence, slope and training shows that these variables determine the level of efficiency positively. On the contrary, age of the household heads and number of livestock unit have inverse related with allocative and economic efficiency level of the farmers in the area.

In Yami *et al.,* (2014), a Translog production function approach was used to investigate the Source of technical inefficiency of smallholder wheat farmers in selected waterlogged areas of Ethiopia. Their result indicated that the mean technical efficiency of wheat farms of 0.55 and access to input and output market has a positive effect on efficient wheat production thereby integration of improved wheat production with the input and output market plays a significant role in enhancing the technical efficiency of wheat producer farmers. Thus provision of input (improved seeds, fertilizer, pesticides herbicides and fungicides) and output market facilities raises farmers' wheat production efficiency level.

Ahmed *et al.,* (2014) used a Cobb-Douglas stochastic frontier production analysis approach with the inefficiency effect model to analyze the technical efficiency in maize production of smallholder farmers in central rift valley of Ethiopia. Their result shows that the mean technical efficiency of the farmers in the production of maize as 88 percent. The estimated stochastic production frontier (SPF) model indicates that

DAP fertilizer, Area, Labor, seed and oxen as significant determinants of maize production level. The estimated SPF model together with the inefficiency parameters shows that frequency of extension contact, access to credit and number of weeding positively and significantly determining the technical efficiency level and family size distance to market negatively and significantly determined technical efficiency level of the farmers in maize production in the study area.

Getachew and Bamlak (2014) used a stochastic frontier approach to analyzed technical efficiency of small holder maize growing farmers of Horo guduru wollega zone. Their result indicated inefficiency in the production of maize in the study area. The relative deviation from the frontier due to inefficiency was 85 percent. The average estimated technical efficiency for smallholder maize producers ranges from 0.06 to 0.92 with a mean technical efficiency of 0.66 (66%). The analysis also reveals that the educational level of the farmer, age of household head, land fragmentation, extension services, engagement in off-farm/non-farm activities, and total land holding of the farmer are the major socio-economic factors influencing farmers' technical efficiency and maize output.

Bachew *et al.*, (2015) conducted smallholder *teff* productivity and Efficiency analysis in High-Potential Districts of Ethiopia. They applied data envelopment analysis to measure smallholder *teff* producers' relative productivity and efficiency. Their result indicated that sex, education level, household size, area, tropical livestock unit and production information positively affected total factor productivity and efficiency and age, number of crops household cultivated, average area of plots household cultivates , average distance between plots and household participation are negatively affect total factor productivity and efficiency.

Hailemaraim (2015) used a Cobb-Douglas stochastic frontier production analysis approach with the inefficiency effect model to simultaneously estimate technical efficiency and identify the determinants of efficiency variations among *Teff* producer farmers in Bereh District. From his result maximum likelihood parameter estimates showed that *Teff* output was positively and significantly influenced by area, fertilizer, labor and number of oxen. The estimated mean level of technical efficiency of *Teff* producers was about 72 percent. His result also indicated that Fertility status of the farm, off-farm occupation; education, credit service, and extension contact determining technical efficiency positively and significantly. However, age of the household head, family size, number of farm plot, and total farm size were found to reduce farmers' technical efficiency.

Wudineh and endrias (2016) employed the stochastic frontier and translog functional form with a one-step approach to assess efficiency and factors affecting efficiency in wheat production. From their result the maximum likelihood estimates for the inefficiency parameter depicted that most farmers in the study area being not efficient. The mean technical efficiency was found to be 57%. Factors such as sex, age and

education level of the household head, livestock holding, group membership, farm size, fragmentation, tenure status and investment in inorganic fertilizers affected efficiency positively and distance to all weather roads negatively affected. The finding implies presence of an opportunity to improve technical efficiency among the farmers by 43% through gender-sensitive agricultural intervention, group approach extension, and attention to farmers' education, scaling out of best farm practices.

Hassen (2016) employed SPF to measure the level of technical efficiency and identify its determinants in wheat crop for smallholder farmers in south Wollo Zone, Ethiopia. his result showed that the average technical efficiency of wheat production in the study area was 79 percent indicating a good potential for increasing wheat output by 21 percent with the existing technology and levels of inputs. His econometric results of stochastic production function indicated area, seed, fertilizer, man days and oxen days positively affecting the technical efficiency.

SUMMERY AND CONCLUSION

The major grain crops grown in Ethiopia are *teff*, wheat, maize, barley, sorghum, and millet. Out of the total grain production, cereals account for roughly 60% of rural employment and 80% of total cultivated land. In the crop production sub-sector, cereals were the dominant food grains. The major crops occupy over 8 million hectares of land with an estimated annual production of about 12 million tons. The potential to increase productivity of these crops is very high as it has been demonstrated and realized by recent extension activities in different parts of the country. However, population expansion, current low productivity due to lack of technology transfer and decreasing availability of arable land are the major contributors to the current food shortage in Ethiopia. Various staple crops dominate different parts of Ethiopia; however, *teff* is either the principal staple or among the most consumed crops in almost all parts of the country. Moreover, the demand for *teff* is elastic with respect to income.

Reducing inefficiency (increasing efficiency) is the best way to enhance productivity. Inefficiency is the inability of the farm to produce maximum possible output with a given bundle of inputs. Different studies have indicated that the existence of inefficiencies in the agricultural sector of Ethiopia. The efficiency level is different from farmer to farmer and place to place. This indicates the possibility of increasing productivity by improving efficiency without increasing the resources base or developing new technologies

The primary objective of this seminar was to review determinants and level of technical efficiency of *teff* production system in Ethiopia. This was achieved by reviewing the efficiency of smallholder *teff* farmers and identifying the determinants of technical efficiency.

The review result suggests that DEA and SPF models are used to estimate level of technical efficiency and identify determinants of technical efficiency, and amount of output and efficiency in the utilization of production input could be obtained significantly by paying more attention to the determinants of technical efficiency. Some of the areas which demand more attention were availability of improved seed and adoption of recommended management practices of farmers in *teff* cultivation. In addition Income level, education level, livestock holding, extension contact, training, participation in irrigation, labor availability, fertilizer, participation in soil and water conservation, off/non-farm occupation, sex of the household, fertility status of land, credit availability, man day, oxen day, pesticides, herbicides, access to input and output market, number of weeding, family size, group membership, Households` expenditure, farm size, participation in share cropping, social status, age of the household, slop of the farm, number of crops cultivated by the households, distance of market, distance of farm from household residence and land fragmentation are found to affect level of farmers' technical efficiency. These factors can either affect efficiency positively or negatively and most of those factors are location specific. That is, a factor which has positive impact on technical efficiency at a particular locality at one time was found to appear with the opposite effect or become irrelevant in another locality. It follows from these findings that we cannot identify universally defined factors either hindering or enhancing or not affecting technical efficiency of farmers. Therefore, undertaking studies on farm households' efficiencies in different localities help the policy makers and other development workers to design and implement an appropriate policy intervention. It was also indicated that a number of factors can affect the efficiency level of farmers, but these factors are not equally important and similar in all places at all time. A decisive factor in one place at certain time may not necessarily be a significant factor in other places or even in the same places after some time. Therefore, policy implications drawn from some of the above empirical works may not allow in designing area specific policies to be compatible with its socio-economic as well as agro-ecologic conditions. Moreover the level of technical efficiency of *teff* production in Ethiopia falls on between 55% and 90% indicating a good potential for increasing *teff* output by 10%-45% with the existing technology and levels of inputs.

Abbreviations

GDP; Gross Domestic Production; NBE: National Bank of Ethiopia; OLS: Ordinary Least Square; SFA: Stochastic Frontier Analysis; SPF: Stochastic Production Frontier; TE: Technical Efficiency; TLU: Total Livestock Unit; UN: United Nations

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