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Review Article

Review on Determinants of Economic Efficiency of Smallholder Maize Production in Ethiopia

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Abstract: Maize is Ethiopia‘s staple crop and is widely grown by smallholder farmers in most part. However, the productivity of this crop is remaining low relative to the potential available in the country. These have aggravated the food insecurity situation by widening the gap between demand for and supply of food. In Ethiopia, information on the determinants of economic efficiency and levels of smallholder maize production is lacking. This paper was aimed at reviewing the determinants of economic efficiency and the level of technical, allocative and economic efficiency of smallholder maize production in Ethiopia. In these review determinants like age, sex, education, livestock holding, frequency of contact with extension agent, participation in off/non-farm income, household perception, credit use, distance, mobile use, land fragmentation, land ownership and soil fertility were identified as the main determinants of economic efficiency of smallholder maize production in Ethiopia. The level technical, allocative and economic efficiency were different author to author through the review. This indicated that the smallholder maize producer in Ethiopia encountered the problem of inefficiency in maize production. Hence, planning and implementing suitable policy intervention by focusing on the abovementioned determinants are important in Ethiopia.

Keywords: Determinant, Economic Efficiency, Ethiopia, Maize, Production, Smallholder

1. Introduction

Maize (*Zea May L.*) was originated in America and it is the world’s third most important food crop next to rice and wheat. It was introduced to Ethiopia during the late 16th or early 17th century. Since its introduction, it has gained much importance and at present stands first in total annual grain production and second in terms of area coverage among cereals in Ethiopia [21]. It is also Africa’s second most important food crops, after cassava, it is grown in a wide range of environment. Per capita consumption of maize in Africa is highest particularly in eastern and southern Africa. Maize is processed to offer various product ranges, which include whole maize meal flour, sifted maize meal, vegetable oil, flour for confectionery, dough, corn flakes, snacks and crackers, starch converted to process sugars like glucose syrup and dextrose [37].

Ethiopia is one of the world’s centers of genetic diversity in crop germplasm produces more of maize than any other crops [15]. Maize is Ethiopia‘s staple crop and is widely grown in most part by smallholder farmers throughout the country. In 2018, maize production was 4.2 million tones, 40% higher than teff and 75% higher than wheat production. With an average yield of 17.4qt per hectare (equal to 3.2 million tones grown over 1.8 million hectares) from 2015 to 2017, maize has been the leading cereal crop in Ethiopia since the mid-1990s in terms of both crop yield and production [46]. However, a study by the [56] in Ethiopia reveals that the number of farmers engaged in maize cultivation and Eight million smallholder farmers are involved in maize production during 2012/13 production season. When maize production compared to 5.8 million for *teff* and 4.5 million for sorghum which are, the second and third most cultivated crops in Ethiopia, respectively [55].

In developed countries, 70% of maize is destined for feed, 3% consumed directly by humans and the remaining 27% uses for bio-fuels, industrial products, and seed. While in Sub-Saharan Africa, 77% of maize is using as food and only 12% serves as feed [31]. Ethiopia is one of the largest grain producing countries in Africa. Though Ethiopia is a net importer of grain, it is the largest maize producer in sub-Saharan Africa. In Ethiopia, cereals are the major food crops both in terms of area coverage and volume of production [27].

The major cereal crops grown in Ethiopia are teff, wheat, barley, maize, sorghum and millet [25]. Maize is one of the major five staple cereal crops in Ethiopia. Among crops grown in Ethiopia, maize is the most important cereal crop in terms of total production, area coverage and better availability and utilization of new production technologies [15]. It is the highly demanded food crop in the South -western part of Ethiopia.

Several efficiency studies have been conducted in different part of Ethiopia on determinants of economic efficiency of smallholder maize production. However, the findings of authors were different from place to place. As far as the author is concerned, there is no similar empirical works that has been undertaken to estimate the level of technical, allocative and economic efficiency and factors that determine efficiency of smallholder maize producer in Ethiopia. Also, the information available on determinants of economic efficiency of smallholder maize production is limit. Therefore, this review intended to assess the determinants of economic efficiency and the level of technical, allocative and economic efficiency of smallholder maize production in Ethiopia.

2. Discussions

2.1. Concept and Definition of Terminologies

The first theoretical framework for efficiency definitions and types of firms' performance analysis was introduced by the famous scholar [23]. He had extended the earlier novel works of [36], who laid the foundation by introducing the concept of efficiency and the way firms' performance could be measured at the firm level in considering the input-output relationship. Efficiency in production refers to scarce resources being used in an optimal fashion [29]. In production economics, efficiency can be understood in terms of a firm's ability to convert inputs into outputs and respond optimally to economic signals or prices [20]. It is the act of achieving good result with little waste of effort.

According to Farrell [23], there are three types of efficiency: Those are allocative (price) efficiency, technical (physical) efficiency and economic (overall) efficiencies. The first type of efficiency is an allocative efficiency (AE), which refers to the capacity of the firm to use a set of inputs in optimal proportion with the given price and level of technology or it could be alternatively interpreted as the ability of a firm to produce a given level of output using cost minimizing input ratios. In welfare economics, allocative efficiency is generally considered as the benefit of the society [45]. The second type of efficiency is technical efficiency (TE), which can be defined as the performance of the given firm to obtain maximum output from a given combination of input used with the given level of technology [23]. The given firm is technically efficient, when the combination of inputs or resources give rise to the utmost possible outcome and has no space for further enhancement of the output of the firm. Furthermore, it can be expressed as the physical relationship between inputs or resources and the final outcome or output. In a circumstance where the firm produced the same amount of output or larger than the previous production level while decreasing the use of at least one of the input in the production process, roughly indicates the existence of inefficiency in the production process.

The third type of efficiency is economic (production) efficiency, which is overall performance measure and is equal to the product of Technical Efficiency (TE) and Allocative Efficiency (AE) (i.e. EE=TE X AE). Therefore technical and allocative efficiency are components of economic efficiency [1, 4, 51]. An economically efficient input-output combination would be on both the frontier function and the expansion path. On the other hand, economic efficiency (EE) refers to the appropriate alternative of inputs and outputs combination according to their price relation or the ability of the firm to maximize profit by equating marginal revenue product of inputs to their respective marginal costs.

According to Farrell [23]., if a farm has attained both technically and allocatively efficient levels of production, it is economically efficient and new investment streams may be critical for any new development. Productivity enhancement can be reached due to the improved technical, allocative and economic efficiency, technological progress or changes in the scale of production [14]. Efficiency, which is a central issue in production economics, is helping as a guide for allocation of resources [23]. In developing countries like Ethiopia, the best option for productivity improvement is increasing the efficiency of producers.

Efficiency: It is the act of achieving good result with little exertion of efforts. It is the act of harnessing material and human resources and coordinating these resources to achieve better management goal [9]. Farrell et al. [22] distinguished between types of efficiency such as Technical Efficiency (TE), Allocative Efficiency (AE) and Economic Efficiency (EE), by which it can be measured in terms of all these type of efficiency. The appropriate measure of technical efficiency is input saving which gives the maximum rate at which the use of all the inputs can be reduced without reducing output

Technical efficiency: it reflects the ability of a firm, country or university to obtain maximal output from a given set of inputs and technology. It is measured by the output of the firm relative to that which it could attain if it were 100% efficient, i.e. if it lay on the frontier itself, and is therefore bound between zero and one [42]. Technical efficiency is concerned with the efficiency of the transformation of inputs to physical output. That is, for efficient production, farm output should lie on the envelope curve, or production function, which traces out the maximum quantities of output from varying quantities of inputs under a given technology. When technical efficiency is defined in terms of maximum output from a given bundle of measured inputs, only those farmers who are technically efficient is operate on the production frontier. A farmer whose input- output performance falls below the production function is technically inefficient [17]. According to the neoclassical definition of technical efficiency, firms are efficient and whatever inefficiency comes in the process of production is due to external shocks or statistical noise which is entirely beyond their control. Furthermore, a production process is technically efficient if and only if it yields the maximum possible output for a specified technology and input set. The concept of efficiency can be explained more easily using input or output oriented approaches. The input oriented measure of efficiency addresses the question "by how much can input quantities be proportionally reduced without changing the output quantities produced?" [14].). A farm can be on or above the unit iso-quant on the input per unit of output space and cannot be below or to the left to it. A departure from the unit iso-quant indicates technical inefficiency and the more a farm were far from the unit iso-quant, the more it is inefficient.

Allocative efficiency: deals with the extent to which farmers make efficiency decisions by using inputs up to the level at which their marginal contribution to production value is equal to the factor cost. Technical and allocative efficiencies were components of economic efficiency [35]. Economic efficiency is concerned with the realization of maximum output in monetary term with the minimum available resources.

Decision makers are increasingly faced with the challenges regarding reconciliation of the growing demand for agricultural output and low agricultural production in developing countries like Ethiopia. This made them to modify development policies and strategies so that limited economic resources (land, labor, capital and entrepreneur ability) are used to produce greater output. Despite the fact that, efficiency is a significant factor for all developing countries where agriculture is the main stay of their people through its contribution is high in agricultural production stability [10].

The efficiency of a firm is its ability to produce the greatest amount of output possible from a fixed amount of inputs [4]. It is the act of harnessing materials and human resources and coordinating these resources to achieve better management goal. The question of efficiency in resource allocation in traditional agriculture is crucial. It is widely held that efficiency is at the center of agricultural production. This is because the scope of agricultural production can be expanded and sustained by farmers through efficient use of resources [7, 53, 28]. For these reasons, efficiency has remained an important subject of empirical investigation particularly in developing economies where majority of the farmers are resource-poor [54, 20].

The crucial role of efficiency in increasing agricultural output has been widely recognized by researchers [28, 44].; [26] among others) and policy makers alike. Because, efficiency of a farm is an indicator to its success in producing as large amount of output as possible given a set of inputs. Moreover, for determination of efficiency of a particular firm, there is a need for efficiency measurement through the production factor inputs and processes [43]. It is impossible to get identical yields with utilization of completely equal amount and quality of inputs [20].

There are discrepancies in the amount and values of inputs and outputs as well as profit ratios of producers [38]. These discrepancies in productive efficiency of producers mainly stem from differences in technical qualifications and unfavorable exploitation of resources. The evaluation of success of the enterprise in terms of effective use of inputs which includes land, labor, seeds, chemicals, water and energy and maintenance of a thorough cost structure lies in the efficiency analysis of the process [44].

2.2. Reviews on Methods for Estimation of Economic Efficiency

Economic efficiency measurements were carried out using frontier methodologies, which shift the average response functions to the maximum output or to the efficient firm. Many empirical studies of efficiency were devoted in analyzing what impact a given model specification has on the efficiency measurements. Various issues concerning to model specification were still debatable. The selection of specific frontier model depends upon many considerations such as the type of data, cross-sectional or panel data, the underlying behavioral assumptions of firms, the relevance to consider and extent of noise in the data and the objective of the study ([14].

The frontier methodologies have been widely used in applied production analysis. Despite these wide arrays of applied work, the extent to which empirical measures of efficiency were sensitive to the choice of methodology remains a matter of controversy [42]. When discussing the performance of firms or decision-making units, it is common to describe them in terms of 'productivity' or 'efficiency'. Though 'productivity' and 'efficiency' were not precisely the same things, both of them were good indicators to evaluate the performance of firms / production units. Efficiency is defined as the ratio of observed output to the maximum potential output that can be attained from given inputs while productivity is the ratio of the output to the input [41].

The large number of frontier models that have been developed based on Farrell's work can be classified into two basic types: parametric and non-parametric. Parametric frontiers, which rely on a specific functional form, can be separated into deterministic and stochastic. The parametric models were basically estimated based on econometric methods and the nonparametric technical efficiency model, often referred to as data envelopment analysis (DEA), involves the use of linear programming method to construct a non-parametric 'piecewise' surface (or frontier) over the data [14].

2.2.1. Overview of Non Parametric Frontier Estimation Methods

One of the methods of measuring efficiency in agricultural production is the non parametric approach of the Data Envelopment Analysis (DEA). It was first introduced by [22]. based on the Farrell's approach. The principal and most commonly used non-parametric frontier model in the analysis of efficiency is DEA. Based on [22] influential work was the first to introduce DEA approach to estimate efficiency. Since its introduction, the approach has served as the corner stone for all subsequent developments in the non-parametric approach to the measurement of technical efficiency.

The DEA frontier is both non-parametric and non-stochastic. As pointed out by several authors [14, 30], DEA strategy has several advantages. It is a non-parametric technique that does not require a prior specific functional form for the production frontier since it does not impose any a priori parametric restrictions on the underlying frontier technology (because doesn't necessitate any functional form to be specified for the frontier methodology) and doesn't require any distributional assumption for the technical efficiency term. In addition, multiple outputs and multiple inputs without necessarily being aggregated can be handled in DEA technique. Furthermore, it is possible to identify the best practice for every decision-making unit under consideration and estimate the output or cost gap of inefficient firms to be fully efficient. Regarding its potential weaknesses, however, apart from its sensitivity to extreme observations, a hypothesis testing at the first stage of DEA is not possible. Moreover, the technique attributes all deviations from the frontier (best practice) to resource use inefficiency.

The two basic DEA models were named after the respective researchers to first introduce them: the Charnes Cooper Rhodes and the Banker Charnes Cooper models [12]. The type of their envelopment surfaces and orientations normally distinguishes the two models. The envelopment surfaces include the form depicting a constant-return-to-scale (CRS) or variable return-to-scale (VRS) represented in the Bio models, respectively [32]. The main advantages of the DEA approach were that it can handle multiple inputs and multiple outputs and that it avoids the parametric specification of technology as well as the distributional assumption for the inefficiency term. However, because DEA is deterministic and attributes all the deviations from the frontier to inefficiencies, a frontier estimated by DEA is likely to be sensitive to measurement errors and other noise in the data [14].

The above DEA model represents input-oriented CRS efficiency measurement. This can also be done for output-oriented problem. In addition, the model can be relaxed to consider different sets of problems such as VRS, to make it fit for scale inefficiencies that could be allocative and economic efficiency. The constant return to scale (CRS) assumption is only appropriate when all firms were operating at optimal scale. Imperfect information, government regulation and constraints on finance etc may cause a firm to be not operating at optimal scale. The use of VRS specification permits to compute technical efficiency devoid of these scale efficiency effects. $SE=TE_{CRS}/TE_{VRS}$

The VRS analysis is more flexible than the CRS analysis; the variable return to scale (VRS) technical efficiency measure (Θ^{VRS}) is equal or greater than CRS measure (Θ^{CRS}). The relationship is used to obtain a measure of SE (Scale Efficiency). $SE=\Theta_t^{CRS}/\Theta_t^{VRS}$Where, SE=1 indicates SE (CRS) and if SE<1 indicates scale inefficiency. Scale inefficiency is due to the presence of either increasing or decreasing returns to scale, which can be determined by solving non-increasing returns to scale.

In these models, the identification of determinants of inefficiency effects requires a second stage analysis. In the second stage, efficiency indices was regressed upon socioeconomic variables that can be estimated through identification of factors associated with technical efficiencies. However, the main criticism of DEA is that it assumes all deviations from the frontier were due to inefficiency. Due to this, non-parametric frontier methodology may exaggerate inefficiencies and hence outliers may have profound effect on the magnitude of inefficiency was [30].

2.2.2. Overview of Parameter Frontier Estimation Methods

Parametric frontier model can further be classified into deterministic and stochastic frontier methods. Typically, both models use econometric techniques to estimate the parameters of pre specified functional forms. However, the deterministic model assumes that any deviation from the frontier is due to inefficiency, while the stochastic approach allows for statistical noise (such as measurement error, weather, industrial action, etc) which, are beyond the control of the decision making unit (in this case the household head). This parametric model uses econometric technique for efficiency analysis which relies on a specific functional form. The parametric models were basically estimated based on econometric methods [14].

(i) Overview of the Deterministic Frontier Approach

One of the most commonly used efficiency measurement under the deterministic approach was proposed by Farrell et al. [22] is called deterministic parametric approach. He proposed computing a parametric convex hull of the observed input-output ratios with the help of Cobb-Douglas production function. He noted the advantage of specifying the functional form in measuring degrees of inefficiency in expressing the frontier in a mathematical form. The main feature of the deterministic frontier is that it assumes that all firms share a common family of production, cost and profit frontiers and all variations in the firm's performance were attributed to variations in the firm's efficiency.

The main criticism of the deterministic frontier model is that it does not account for possible influence of measurement error and other noise upon the shape and positioning of the estimated frontier [14]. All observed deviations from the estimated frontier were thus, assumed to be the result of technical inefficiency. Therefore, the method sums up all the effects of exogenous shocks together with measurement errors and inefficiency. Due to the limitations of the deterministic parametric frontier approach led to the development of the other variant of the deterministic measurement approach, a model known as deterministic statistical frontier. This model was explicitly proposed by [3] which involves statistical techniques and assumptions to be made about statistical properties of the frontier model. The deterministic parametric frontier approach is formulated with the production behavior of firms. It can be expressed as; $Yi=f(Xi,\beta)\exp^{(-Ut)}i=1,2$-------NWhere f (Xi;β) is a suitable functional form, is vector of unknown parameters, U assesses the socioeconomic, institutional and technological factors that were responsible for low production and productivity of the firm. Ui is a non-negative random variable associated with technical inefficiency of the ith firm which implies that exp (-Ui) is bounded between 0 and 1 while Yi is the vector of output. Those observations on U were independently and identically distributed, and that X is exogenous (independent of U). [3] proposed a two parameter Beta distribution for U, which is the model to be estimated by maximum likelihood method.

The technical efficiency of the ith firm is indicated by the factor by which the actual (observed) production deviates from the frontier (potential) output. Hence, the ratio of the observed output for the ith firm, relative to the potential output, defined by the frontier function, given the input vector, xi, is used to define:

$$TE= Yi/\exp(xi\ \beta) = \exp(xi\ \beta\text{-}\mu i)/ \exp(xi\ \beta)= \exp(\text{-}\mu i)$$

[42] developed the probabilistic frontier to the outliers in the above deterministic estimation approaches. The deterministic model considers that any deviation from the frontier is due to inefficiency. Hence, when there is high random error on the data, the inefficiency estimates was exaggerated as compared to other models, which take into account random errors.

(ii) Overview of Stochastic Frontier Approach

The stochastic frontier approach which was introduced in order to overcome the problem associated with random error in the deterministic approach an alternative estimation method by Meeusen [39] and Aigner *et al.* [5], reversed the conventional belief that deviations from the production frontier were 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. 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 stochastic production frontier was developed by adding a symmetric error term (vi) to the non-negative error term of the equation in (1) as: Ln(yi)=F(Xi,β)+Vi-Uii=1.2------N

In this equation the vis' are assumed to be independent and identically distributed random errors following a normal distribution with zero mean and variance σv^2. The random error accounts for measurement error, and other external factors such as climatic changes in production process which is out of the control of the producer; whereas the uis' were the technically inefficiency terms which were associated with the technical inefficiency of the firms.

In the prediction of firm level of technical efficiencies, [14]. pointed out that the best predictor of exp (-μi) is obtained by:

$$\mathrm{E}(\exp(-\mu_i)\ /\ e_i) = \frac{1-\Phi\left(\sigma_A + \frac{\gamma \pounds_i}{\sigma_A}\right)}{1-\Phi\left(\frac{\gamma e_i}{\sigma_A}\right)} \exp(\gamma e_i + \sigma^2/2)$$

Where

$\sigma_A = \sqrt{\gamma(1-\gamma)\sigma_S^2}$; $e_i = \ln(y_i) - x_i\beta$; (.) is the density function of a standard normal random variables which can be estimated by maximum likelihood once the density function for μ is specified.

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 ith farm to the corresponding production value if the farm effect U is 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 Ui, which cannot be justified given the present state of knowledge [14].

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 [48].

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 were 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 [49].

(iii) Overview of Cobb - Douglas Production Function and Efficiency

Estimation of efficiency and production functions is one of the most popular areas of research. Production is the process through which some goods and services called inputs are transformed into other goods called products or output. Production function is a systematic and mathematical expression of the relationship among various quantities of inputs or input services used in the production of a commodity and the corresponding quantities of output [2]. In particular, it shows the maximum level of output the firm can produce combining the existing inputs [11]. A particular production function can be specified as: F(x)=max(yi:T(xi,yi))

The level of output can be enhanced in many ways. Firstly, by expanding the level of inputs used in production. This approach is called "horizontal expansion". However, increasing use of inputs is possible if either the price of output increase or the price of inputs decreases. Secondly, output can be increased by enhancing efficiency in production [2]. This approach is termed as "improvement approach" and requires the improvement of socio-economic, institutional and environmental constraints to enhance production using the existing inputs. Thirdly, output can be also increased by improving the technology in production. This includes use of improved techniques of production, improved seeds, modern fertilizer and chemicals. This approach is termed the "transformation approach" [6].

The theory explains the factors of production; resources/inputs are what are used in the production process to produce output that is, finished goods and services. The amounts of the various inputs used determine the quantity of output according to a relationship called the "production function". The basic resources or factors of production are land, labor, and capital. These factors are also frequently labeled "producer goods" to distinguish them from the goods or services purchased by consumers, which are frequently labeled as "consumer goods." All three of these are required in combination at a time to produce a commodity. The essence of a firm is to buy inputs, convert them to outputs, and sell these outputs to consumers and the firm owners seek to improve their positions by producing goods and service either those they consider most important for themselves or those that can be sold to command the goods they consider most important [52]. Cobb–Douglas production function is a particular functional form of the production function, widely used to represent the technological relationship between the amounts of two or more inputs, particularly physical capital and labor, and the amount of output that can be produced by those inputs. The term has a more restricted meaning, requiring that the function display constant returns to scale in which case $\beta = 1 - \alpha$. In its most standard form for production of a single good with two factors, the function is: $Y=AL^{\beta}K^{\alpha}$

2.3. Measurement Approach in Analyzing Determinants of Economic Efficiency

Two approaches in analyzing the determinants of economic efficiency using stochastic frontier production function.

2.3.1. Two Stage Estimation Approach

These involves the estimation of the technical efficiency effects from models and regressing these on a set of farm and farmer; specific characteristics. In this approach, the two-stage estimation procedure is used to estimate stochastic production to derive efficiency scores. After the efficiency scores are derived in the first stage, the second stage follows where the derived efficiency scores are regressed on explanatory variables using ordinary least square (OLS) methods or Tobit regression. This approach, though widely used, it implies that the inefficiency effects which are assumed to be independently and identically distributed in the estimation of the stochastic frontier are a function of the farm specific effects in the second stage, thus violating the assumption that the efficiency effects are identically distributed [14].

The above approach has been criticized on the grounds that the firm's knowledge of its level of economic inefficiency affects its input choices; hence inefficiency may be dependent on the explanatory variables. The inefficiency effects would only be identically distributed if the coefficients of the farm specific factors were simultaneously equal to zero. It is possible to overcome this problem by the use of a single stage maximum likelihood approach [14].

2.3.2. Single Stage Simultaneous Approach

The single stage approach advocates a one stage simultaneous estimation approach in which the inefficiency effects were expressed as an explicit function of a vector of farm-specific variables. The technical inefficiency effects were expressed as$U_j= Z\delta$Where for farm j, Z is a vector of observable explanatory variables affecting economic efficiency and δ is a vector of unknown parameters. Thus, the parameters of the frontier production function were simultaneously estimated with those of an inefficiency model, in which the economic inefficiency effects are specified as a function of other variables. The one stage simultaneous approach could be estimated in FRONTIER [14]. The program provides basic parameters and coefficients for the economic inefficiency model. Hence several factors, including socioeconomic and demographic factors, plot-level characteristics, environmental factors, and non-physical factors are likely to affect the efficiency of farmers.

2.4. Review on the Determinants of Economic Efficiency of Smallholder Maize Production in Ethiopia

This section reviews the effects of some of important demographic, socio economic and institutional factors on efficiency of smallholder maize producers in detail.

Important determinant that affecting the efficiency of smallholder maize producers were found to be oxen holding, farm size, use of maize seed, education level, use of fertilizer, herbicides, farmers' age and experience, distance of the plot to the main access road, household size/labor, gender, usage of hand hoe, off farm income, farmers' membership to associations, access to development agents, and access to credit [13, 19, 18, 57].

Older farmers are more experienced in farming activities and are better to assess the risks involved in farming than younger farmers [47]. As a result, age of household head contributes positively to technical efficiency. This implies that as age of the decision maker increases, technical efficiency will increase. This may be perhaps due to the fact that farmers learn from their experience about the allocation of inputs [20].

In addition to this, Zalkuwi [57] identified that older farmers in maize production are more cost efficient than younger ones. However, this is in disagreement with the analyses of Boris [13] and Khan and Saeed [33] which showed that age contributes negatively to efficiencies, meaning that younger farmers were relatively more efficient than older farmers. This is an important finding which notes that younger farmers are comparatively more educated than older farmers. Thus, they inferred from their finding that the younger and educated the farmer, the more technically and economically efficient he is. Similarly, findings of Simonyan et al. [50] explained that younger farmers were technically efficient than their aged counterparts.

Tolesa *et al*. [51] conducted study on economic efficiency of smallholder farmers in maize production in Ethiopia and used Tobit model to estimate the determinants. The model results revealed that education levels, family size, farm size, frequency of extension contact, uses of credit and participation in off/non-farm activities had a significant positive effect on technical efficiency. Livestock holding and participation in off/non-farm activities had positive effect and distance of maize plot from home were found to had negative effect on allocative efficiency while education levels, family size, uses of credit, extension contact and participation in off/non-farm activities were found to had positive effect and distance of maize plot from home is negative influence on economic efficiency.

Bealu *et al.* [8] studies conducted on factors affecting economic efficiency in maize production in Ethiopia, based on data collected from 204 randomly selected farmers, indicated as there was significant level of inefficiency among maize farmers. According to their studies, by using Tobit regression model estimation revealed that economic efficiency was positively and significantly affected by education, training, membership to cooperatives, access to credit, and family size whereas variables such as age, distance to extension officers, distance to market, livestock and off farm income affected it negatively.

Debebe *et al.* [16] studies indicated a substantial level of inefficiency in maize production. The result revealed that a number of family size, level of education, extension service, cooperative membership, farm size, livestock holding and use of mobile are important factors that affected technical, allocative and economic efficiency.

According to Mustefa *et al*. [40] studies, indicated that education level of the sample household was the most important factor that found to be statistically significant to affect the level of technical, allocative and economic efficiency all together. Whereas, land fragmentation and soil fertility were the major factors that affect the level of technical efficiency. Besides, land fragmentation, livestock ownership and frequency of extension contact were important factors that affect allocative efficiency of farmers. The results also further revealed that extension contact was the most important factors that found to be statistically significant to affect economic efficiency.

According to Kifle *et al*. [34], age, off/non-farm activities, sex, amount of land owned and perception on agricultural policy had a significant effect on technical efficiency. Education, frequency of extension visit, perception on agricultural policy and livestock holding had significant effect on allocative efficiency while age, off/non-farm activities, sex, land owned, credit utilized and perception on agricultural policy had a significant effect on economic efficiency. The result showed that there are chance to increase efficiency of maize production.

2.5. Review on the Level of Economic Efficiency of Smallholder Maize Production in Ethiopia

Tolesa *et al*. [51] conducted the studies on economic efficiency of smallholder farmers in maize production in Ethiopia. Their analysis result indicated that, the mean technical efficiency level of 71.65% shows that maize producing could increase the current maize output by 28.35% using the existing technology. The mean allocative efficiency of farmers in the study area was 70.06% indicating that on average, maize producer households can save 29.94% of their current cost of inputs if resources are efficiently utilized. The mean economic efficiency level of sample households was 49.89%. This shows that an economically efficient household can reduce his/her maize production cost by 50.11%. The low level of EE was the total effect of both technical and allocative inefficiencies.

Bealu *et al.* [8] studies conducted on factors affecting economic efficiency in maize production in Ethiopia, based on data collected from 204 randomly selected farmers, indicated as there was significant level of inefficiency among maize farmers. According to their studies, the mean technical and allocative efficiencies were 72 and 70 percent, respectively while the mean economic efficiency was 53 percent.

Ahmed [4] conducted study on economic efficiency of smallholder farmers in maize production. The estimated results showed that the mean level of technical, allocative and economic efficiencies was 84.87%, 37.47% and 31.62% respectively which indicates the significant inefficiency in maize production in the study area.

According to the studies of Debebe *et al.* [16], showed that the mean technical, allocative and economic efficiency score was found to be 62.3, 57.1 and 39%, respectively, indicating a substantial level of inefficiency in maize production.

According to the studies of Mustefa *et al*. [40] on Economic efficiency of maize production showed that the mean technical, allocative and economic efficiencies were 81.78%, 37.45% and 30.62% respectively. It indicated that there was significant inefficiency in maize production.

Kifle *et al*. [34] shows that the mean levels of technical, allocative and economic efficiencies were 82.93%, 66.03% and 54%, respectively. This mean level of technical and allocative efficiencies implies that there exists possibility to increase production by 17.07% without using extra inputs and decrease cost of inputs by 33.97%, respectively. The result revealed high inefficiency among maize producers.

3. Conclusion and Policy Implications

Ethiopia is one of the world's centers of genetic diversity in crop germplasm produces more of maize than any other crops [15]. Maize is Ethiopia's staple crop and is widely grown in most part by smallholder farmers throughout the country. In 2018, maize production was 4.2 million tones, 40% higher than *teff* and 75% higher than wheat production [24]. Ethiopia is the developing country which faces two problems (highly population growth and low level of productivity). Despite different agricultural technologies introduced in the country the efficiency of cereal crop production particularly maize is remain low from the rest of the world.

Even though, maize is one of the cereal crop produced in most part of Ethiopia and has been the second in area coverage and the first in productivity, the studies conducted on the smallholder maize production in Ethiopia found low efficiency in comparison with the rest of the world maize productivity. In order to improve maize production efficiency, an efficient use of production resources has to be adopted by smallholder maize farmers. Thus, raising production levels and reducing its variability are both essential approaches to improve food security and to realize livelihood of the people of Ethiopia.

Different studies were conducted by using different models to analyze the determinants of economic efficiency of smallholder maize production and the result of the review indicate that the important determinants that influence economic efficiency of smallholder maize production are age, sex, education, livestock holding, frequency of contact with extension agent, participation in off/non-farm income, household perception, credit use, distance, mobile use, land fragmentation, land ownership and soil fertility were identified as the main determinants of economic efficiency of smallholder maize production in Ethiopia. The level of technical, allocative and economic efficiency found was different from author to author through this review. This suggested that more research in future in the Ethiopia.

Hence, conducting studies on determinants of economic efficiency of smallholder maize production in different parts of the country by using different models open the way for policy makers and the supporter of development to plan and implement a suitable policy intervention by focusing on the problem previously discussed through this review in Ethiopia.

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