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Analysis of Technical Efficiency of Potato Production: The Case of Smallholder Farmers in Welmera Woreda

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Abstract: In Ethiopia, increasing population pressure and low levels of agricultural productivity have contributed a lot to the food security problems by widening the gap between demand for and supply of food. Increasing productivity in crop production, which among others could be possible by enhancing the level of technical efficiency, is an important step towards enlightening food security. This study was aimed at estimating the levels of technical efficiencies of smallholder potato producer and to identify factors affecting efficiency performances of smallholder farmers in potato production in Welmera district, Oromia National Regional State, Ethiopia. A two stages sampling technique was used to select 150 sample farmers to collect primary data pertaining of 2019/20 production year. Both primary and secondary data sources were used for this study. Cobb-Douglas production function was fitted using stochastic production frontier approach to estimate technical efficiency levels, whereas a two-limit Tobit model was employed to identify factors affecting efficiency levels of the sampled farmers. The stochastic production frontier model indicated that input variables such as land, mineral fertilizers and seed were the significant inputs to increase the quantity of potato output. The estimated mean values of technical efficiency were 73.7%, which indicate the presence of inefficiency in potato production in the study area. A two-limit Tobit model result indicated that technical efficiency positively and significantly affected by age, education, farming experience, TLU, seeding/hoeing frequency, extension contact, frequency of agronomic practice training, access to cooperative, loan, access to work party/Debo, but negatively affected by land fragmentation. In general, the result indicated that there is a room to increase technical efficiency and thereby to increase productivity of potato producers in the study area.

Keywords: Cobb-Douglas, Technical Efficiency, Ethiopia, Smallholder, Stochastic Frontier, Ethiopia

1. Introduction

Potato is grown in most parts of Ethiopia, with the major ones including the central, eastern, northwestern and southern areas which cover approximately 83% of the potato farmers [8]. Finfine Zuria special zone is among the potential high land areas for potato production out of which Welmera woreda is one [9].

Despite its immense potential, the average productivity of potato production on farmers' field is about 7tons/ha in the study area and 13 tons/ha in overall potato growing areas in the country [8, 9].). This is very low as compared to an attainable level (25 tons/ha) on farmers field and about 35 tons/ha on research fields [17].

The observed variation in yield level of potato production on farmers' field and research fields and when compared with the registered national average is an indication that there is a possibility to further increase productivity of potato production in this study area.

The adoption of new technologies has a considerable attention as a means to enhance productivity and economic development. However, output growth cannot be determined by technological innovations only but also by the efficiency with which available technologies are used [18]. Evidences showed that a considerable share of recent potato production growth has come from cultivable area expansion [8, 9].

Hence, potato production in the study area can possibly be raised (1) by allocating more area for production, (2) by developing and adopting of new potato technologies, and (3) by utilizing the available resources more efficiently. Considering the first method would mean trying to boost output at the cost of bringing marginal areas into cultivation. Therefore, to what extent to continue to expand cultivation land remains an important question. On the other hand, creation and introduction of new technologies is a long-term option and requires a lot of capital for research and extension. Rather, in an economy where resources are scarce and opportunities for new technologies are limited, it is possible to raise the productivity in the short run by improving efficiency without raising the resource base or developing new technology [14].

In relation to this, knowing the current technical efficiency level of potato production at smallholder level and identifying the key factors affecting and/or causing variations among smallholder producers in this study area is found very imperative in the course of planning for improvement. In this regard, there was no similar study conducted on similar issue in the specific targeted study kebeles and hence this study is meant to fill this information gap.

Therefore, the general objective of this study is to assess the technical efficiency level of potato producers in the study area and its socio-economic determinants.

2. Literature Review

2.1. Theoretical Framework for Efficiency of Production

The small holder farmers output can be increased through increasing inputs, increasing productivity of inputs and the combination of the two. Hence, efficiency is a central issue in production economics helping as a guide for allocation of resources [10]. Productivity improvements can be achieved in two ways. One can be through improving the state of the technology by introducing new technologies, which leads to an upward shift in the production frontier, or alternatively one can improve efficiency of the farmers using the existing technology more efficiently. The firms operating more closely to the existing frontier would represent this. Therefore, it is evident that increase in productivity achieved through either technological progress or efficiency improvement so that the policies required to address these two issues are likely to be quite different [4].

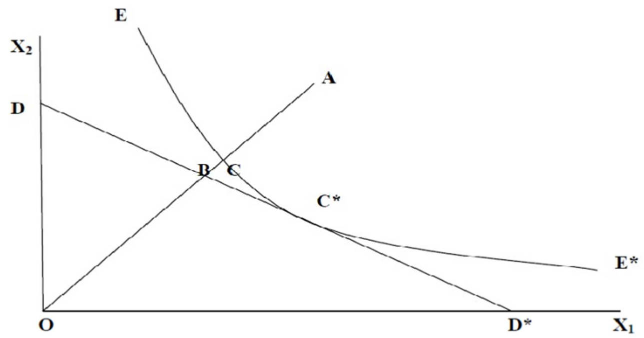
There are two approaches in measuring efficiency: input oriented and output oriented. The output-oriented approach deals with the question "by how much output could be expanded from a given level of inputs?" Alternatively, one could ask, "by how much can input of quantities be proportionally reduced 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 [7].

2.1.1. 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 Figure 1. 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 isoquant 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:

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



Source: Reproduced from Coelli et al [5].

Figure 1. *Input-oriented measures for technical, allocative and economic efficiencies.*

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 isoquant 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:

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

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.

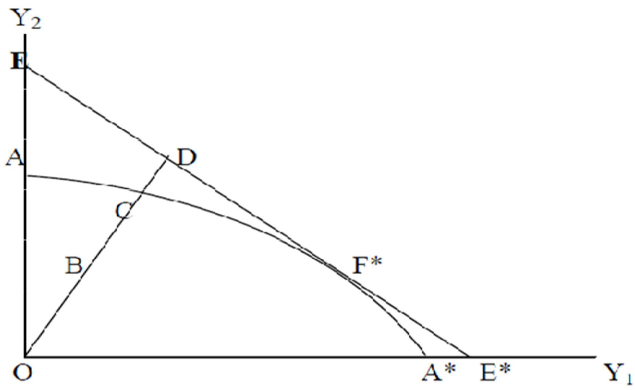
$$EE = TE * AE \quad (3)$$

$$EE = \frac{OC \times OB}{OA \times OC} \quad (4)$$

$$EE = \frac{OB}{OA} \quad (5)$$

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.

2.1.2. Output-Oriented Efficiency Measures



Source: Reproduced from Coelli et al [5]

Figure 2. *Output-oriented measures for technical, allocative and economic efficiencies.*

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.

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:

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

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

2.2. Models of Efficiency Measurement

According to Coelli et al., there are various approaches to efficiency analysis [5]. These include (1) least squares econometric production models, (2) total factor productivity (TFP) indices, (3) data envelopment analysis (DEA) and (4) stochastic production frontiers (SPF). The first two approaches are applied to aggregate time-series data and provide measures of technical change and/or TFP. Both of these approaches assume that all firms are technically efficient. However, approaches 3 and 4 are most often applied to data on a sample of firms (cross-sectional data), provide measures of relative efficiency among firms (ex. farmers), and do not assume that all firms are technically efficient. There is an alternative way of grouping the above approaches, 1 and 4 involve the econometric estimation of parametric functions, while 2 and 3 involve non-parametric functions. Therefore, these two final groups may be termed as "parametric" and 'non-parametric" methods respectively (ibid).

These techniques are generally grouped according to their assumptions about the functional form of production (or cost) frontiers. However, there are no explicit criteria to pick the most relevant approach for constructing the production frontier. the choice of a technique for empirical analysis is arbitrary[15]. Consequently, the following discussion will focus on DEA and SPF methods in general, on SPF in particular. Since these two (DEA and SPF) methods have been used to estimate frontiers and involve mathematical programming and econometric methods respectively.

2.2.1. 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 calculation 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 [7].

$$\text{Min } \varphi\ \lambda\ \Phi \quad (9)$$

Subject to

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

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

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

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 is 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 [10].

Data Envelopment Analysis 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. Thus, it is only for the literature review purposes.

2.2.2. 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.* recommended that stochastic frontier analysis is more appropriate than Data Envelopment Analysis 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, and the like plays a significant role [5].

(i). Deterministic Models

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

$$y_i = \alpha + \beta' x_i - ui \quad (10)$$

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

$$DF_i = \exp(-u_i) \quad (11)$$

It is the Debreu-Farrell measure of technical efficiency. It is not necessary to restrict the production function to Cobb-Douglas [2]. Alternatively, the flexible Translog 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 can be obtained by shifting the OLS line upward so that the largest adjusted residual is zero [11]. 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 is a minor difference 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 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 [2]. 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.

(ii). Stochastic Frontier Model

The stochastic frontier approach of technical efficiency incorporates 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 [3, 12]. 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 [7]. 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 [19].

In stochastic frontier method, technical efficiency is measured by estimating a production function. Different production functions such as Cobb-Douglas, Translog, Transcendental, and Quadratic etc. can be used to estimate the frontier. The Translog 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 [20].

The choice is made based on 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. In fact, the stochastic frontiers method makes it possible to estimate a frontier function that simultaneously takes into account the random error and the inefficiency component specific to potato producing farmers.

2.3. Empirical Review of the Literature

Most empirical studies of technical efficiency targeted on estimating efficiency levels and identifying the sources of efficiency difference among producers. This is because the measurement of efficiency level only has no policy implication unless the real causes of efficiency differences are identified. Frontier production function models have been applied in a considerable number of empirical studies in both agriculture and non-agricultural sectors since the ground-breaking work of Farrell. Some Selected related empirical studies are reviewed below to see the method being followed in efficiency study.

Ahmed *et al* applied Cobb-Douglas stochastic frontier approach for estimation of technical efficiency levels in potato production [1]. The mean technical efficiency of farmers in the production of potato was found to be 0.89. The estimated stochastic production frontier model indicated that area of the plots, amounts of NPS fertilizers, amount of seed and labor in person-days were positive and significant determinants of production level. The estimated SPF model together with the inefficiency parameters showed that age, age square, education, land ownership status, extension contact, number of plots (fragmentation), household size, and livestock significantly determined efficiency level of farmers in potato production in the study area. To this end, the attention of policy makers to improve agricultural production should not revolve solely around the introduction and dissemination of new technology to increase yield, but also more attention should be given to improve the existing level of efficiency.

Wubishet analyzed technical efficiency of potato production by smallholder farmers in Dinsho district, Bale zone of Oromia region. The study used a cross sectional data obtained from a field survey using structured questionnaire from a random sample of 149 smallholder potato producers in the study area. A Cobb-Douglas stochastic frontier production analysis approach with the inefficiency effect model was used to simultaneously estimate technical efficiency and identify the determinants of efficiency variations among potato producer farmers. The maximum likelihood parameter estimates showed that potato output was positively and significantly influenced by area, quantity of urea fertilizer and quantity of seed used. The discrepancy ratio, γ, which measures the relative deviation of output from the frontier level due to inefficiency was 0.76. This implies that about 76 percent of the variation in potato output among the sample respondents was due to technical inefficiency effects. The result of the study further showed significance differences in technical efficiency among potato producers in the district. The single stage estimation result showed that the mean technical efficiency of the farmers was found to be 0.74 and ranged between 0.23 and 0.98 [16]. This tells that there exists an option for farmers to increase the level of potato output on average by about 24 percent through exploiting the existing local practices and technical knowledge of the relatively efficient farmers. The estimated SPF model together with the inefficiency parameters shows that education level, land ownership, fertility status of potato plots and frequency of extension contact negatively and significantly affected technical inefficiency of potato production while land fragmentation positively and significantly affected it. Therefore, any development program aimed at improving technical efficiency of potato production should focus on the above-mentioned factors.

Tadesse *et al.* analyzed the technical efficiency of rice production in Fogera District of Ethiopia. The stochastic frontier approach was employed on a data collected from 200 sample households in the 2015/16 production year. As a result, it was found out that except for manure, all variables in the Cobb-Douglass stochastic frontier model, which includes land, fertilizer, oxen, seed, and labor, were positively and significantly related to rice production. The average technical efficiency score predicted from the estimated Cobb-Douglas stochastic frontier production function was calculated to be 77.2 percent, implying that there was a room for rice yield increment by improving the resource use efficiency of households [22]. The study also revealed that the provision of extension services, training on rice product improvement, experience on rice farming, agrochemicals, and education tend to be positively and significantly related to technical efficiency while household size was negatively and significantly related. Thus, strengthening the extension service provision and the training on rice yield increment, campaigns to disseminate rice farming experiences, and an increase in the supply of agrochemicals were crucial to improve the technical efficiency of rice production in the study area.

Kusse *et al* examined technical efficiency of sorghum production by smallholder farmers in Konso district, Southern Ethiopia using cross sectional data collected from a sample of 124 sorghum-producing households. Individual levels of technical efficiency scores were estimated using the Cobb-Douglas functional form, which was specified to estimate the stochastic production frontier. The estimated stochastic production frontier model indicated that input variables such as land size, fertilizer (Urea and DAP), human labour, oxen power and chemicals (herbicides or pesticides) found to be important factors in increasing the level of sorghum output in the study area [23]. The result further revealed significant differences in technical efficiency among sorghum producers in the study area. The discrepancy ratio, which measures the relative deviation of output from the frontier level due to inefficiency, was about 90%. The estimated mean levels of technical efficiency of the sample households was about 69%, which shows existence of a possibility to increase the level of sorghum output by about 31% through efficient use of the existing resources. Among the household specific socio-economic and institutional factors hypothesized to affect the level of technical inefficiency, age, education level, family size, off/non-farm activities, extension contact, livestock holding, plots distance and soil fertility status were found to be significant in determining the level of technical inefficiency of sorghum production in the study area. Hence, emphasis should be given to improve the efficiency level of those less efficient households by adopting the practices of relatively efficient households in the study area. Beside this, policies and strategies of the government should be directed towards the above-mentioned determinants (ibid).

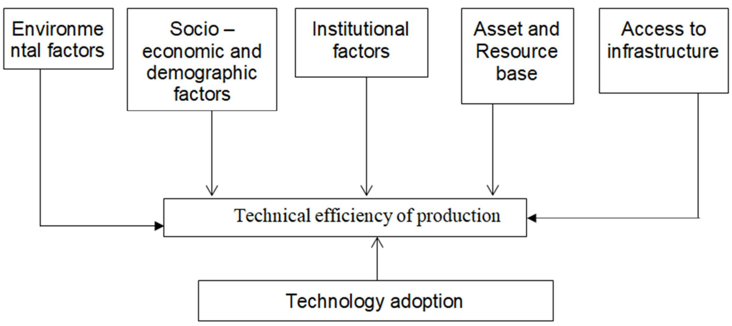
In general, different researches have been conducted on technical efficiency of farmers in different regions using different models and different assumptions of estimation to various sets of variables, in order to measure and identify the level and sources of technical efficiency. These efficiency levels do also vary spatially and temporally. The literatures suggested that from the current level of technology and factor endowment, there is a potential to increase agricultural production by improving the demographic, institutional, and environmental factors.

2.4. Conceptual Framework

Conceptual framework is defined as a network or a plane of interlinked concepts that together provide a comprehensive understanding of a phenomenon. In other words, it is a visual or written product that explains either graphically or in a narrative form, the main things to be studied (key factors, concepts, variables and the presumed relationships among them) [13].

The conceptual framework for this study is shown in Figure 3 below, which represents how various factors inter-relate to influence efficiency, productivity and hence the welfare of small holder *potato* producers.

Production inputs such as amount of seed, fertilizers, area, oxen power and labor are used as input into *potato* production. The availability and distribution of these inputs may be influenced by policy framework in place which in turn determines *potato* productivity. It is expected that more inputs used by the farmers up to recommended level leads to higher *potato* productivity. In addition, *potato productivity* is also affected by technical efficiency because for a production to be efficient, the way in which available inputs are utilized is crucial. However, technical efficiency of farmers is also influenced by farmer's characteristics, cultivated land characteristics, crop specific factors, institutional and socio-economic characteristics of farmers. A farmer who is technically efficient is therefore expected to realize higher *potato* productivity compared to that of less efficient. Therefore, this has a positive spillover effect on the welfare of *potato* producer farmers.



Source: Own construction based on literature

Figure 3. *Conceptual framework of the study.*

3. Data and Methodology

3.1. Description of the Study Area

Welmera is one of the districts in Finfinne Zuria special zone, Oromia Region of Ethiopia. It is bordered with; Sebeta Hawas and Ejere woredas of West Shawa zones from south and west respectively. Mulo and Sululta woredas of North Shawa zone from the north and northeast respectively and Burayu town administration in the east. The highest point in this woreda is Mountain Wochacha which is about 3191 masl located in the southern part of the woreda. The rainfall pattern of the woreda is bimodal, with a short rainy period from February to April and a long rainy season from mid-June to September. The annual temperature and rainfall ranges from 18°C to 24°C and 1000 to 1100 mm, respectively. The major crops grown in the area are potato, teff, wheat, lentils, cereals, and pulse crops. In addition to crop production, livestock production is also common in the area. Livestock production in the area is the source of draft animal power for ploughing and threshing, source of income next to crop production, and it serves as a risk minimization strategy during crop failure as one source of fuel. According to the 2019/20 projection, the population of the woreda reported a total population for this woreda of 83,823, of whom 42,115 were men and 41,708 were women; 3,352 or 4% of its population are urban dwellers.

3.2. Types and Sources of Data

The study will make use of both primary and secondary data sources. The primary data was collected by administering a semi-structured questionnaire to the sampled respondents by enumerators. The enumerators were trained on the content of questionnaire, method of data collection and how to approach household heads during the interview. Relevant secondary data sources were assessed from published and unpublished documents to supplement the primary data.

The major source of data for this study was taken from smallholder farmer's household heads. Data was collected through well-prepared and pretested interview schedule that was administered to the respondents by the trained enumerators.

3.3. Instruments and Methods of Data Collection

In order to conduct this study, out of 23 kebeles of the woreda (14 kebeles with high potato producing potential), 3 kebeles was selected purposively based on their potential for potato production and suitability/accessibility for conducting the study. These are namely, Rob-Gebeya, Talacho and Dufa kebeles.

In order to select sample households, three-stage sampling technique with combinations of purposive and simple random sampling techniques was used. Out of the 6 woredas in Finfinne Zuria special zone, Welmera woreda is purposively selected due to long-year experience and dominant in potato farming according to the information obtained from the zonal Agricultural development office. In the first stage, out of the 14 rural kebeles, potato-producing kebeles, in the woreda, 3 kebeles were purposively selected based on their high production potential, accessibility, and easiness to conduct the study. In the third stage, 150 sample potato-producing farmers were selected using simple random sampling technique from the three selected kebeles based on probability proportional to size sampling technique.

Sample Frame

The sample frames for this study were the potato-producing households from three kebeles (namely Rob-gabeya, Talacho and Dufa) of the woreda. Those 3 kebeles comprises of 245 households who produce potato as a primary crop. Based on this household size proportional sampling was done to make representative from each kebele. Proportionality was calculated from the total potato producing households of those 3 kebeles and based on this percentage their respective sample size was taken.

Sample Size Determination

Again, from four selected kebeles the representative respondents was selected to enhance reliability and validity of the study. Accordingly, the sample size of the study is determined by using Kothari sampling design formula [21]:

$$n = \frac{Z^2 pqN}{e^2(N-1)+Z^2 pq} = \frac{1.96^2(0.5)(0.5)(245)}{0.05^2(245-1)+1.96^2(0.5)(0.5)} = 150 \quad (12)$$

Where;

n = sample size

N = total population (245)

Z = 95% confidence interval under normal curve (1.96)

e = acceptable error term (0.05) and P and q are estimates of the proportion of population to be sampled (P=0.5 and q= 0.5)

Thus, according to the above formula, the number of respondents is calculated to be 150.

3.4. Sources of Data and Methods of Data Collection

For this study, both primary and secondary data was used. Structured questionnaire was used to collect primary data from sample households. The questionnaires was first be pre-tested on selected respondents and based on the results of the pre-test, necessary modifications was made before carrying out of the actual survey.

In each of potato producing respondent households, the household head or any adult who had lived with the household for at least one previous crop production seasons and conversant with the farming activities of the other household members was interviewed. The primary data was supplement by secondary data whenever necessary.

3.5. Methods of Data Collection

The required quantitative data was collected through farm household survey using structured questionnaire. In addition, observation, individual and group discussions are going to be the main methods used. Trained field enumerators were involved in data collection and will then be administered by the researcher. The enumerators were from DAs because they not only have a good knowledge of rural areas, but also are also well known to the farmers. Prior to an interview, objective of the survey would be clearly explained to the respondents. In every farm, interview head of the household, who is considered as the farm manager.

3.6. Method of Data Analysis

With regard to data analysis both descriptive and econometric methods was employed. Descriptive statistics such as mean, standard deviation, percentage and frequencies could be used to analyze the socio economic characteristics of potato producers and to estimate technical efficiency levels of the sample farmers. SPF econometric model that assumed a Cobb Douglas production functional form was employed to analyze technical efficiency level in potato production in the study area.

3.6.1. Descriptive Statistics

This method is used to summarize and analyze the sample respondent households' input use, output levels and their determining characteristics, used in the frontier production and in the (in) efficiency model, respectively.

3.6.2. Econometric Analysis

Specification of the empirical model: Stochastic production frontier is the most appropriate technique for efficiency studies which have a probability of being affected by factors beyond control of decision making unit. This is because of the fact that this technique accounts for measuring inefficiency as a result of these factors and technical errors occurring during measurement and observation. Potato production at the study area is likely to be affected by natural hazards, unexpected weather conditions, pest and disease occurrence which are beyond the control of the farmers. In addition, measurement and observational errors could also occur during data collection. To capture effects of these errors, this study used stochastic frontier model was introduced [2, 3]. The stochastic frontier approach splits the deviation (error term) into two parts to accommodate factors which are purely random and are out of the control of the firm. One component is the technical inefficiency of a firm, and the other component is random shocks (white noise) such as bad weather, measurement error, omission of variables and so on. The model is expressed as:

$$\ln Yi = \beta 0 + \beta_i \ln X_{ij} + \exp(e_i) \qquad (13)$$

where ln = denotes the natural logarithm, i = represent the ith farmer in the sample, Yi = represents yield of potato output of the ith farmer (Qt), Xij = refers to the farm inputs of the ith farmer, ei = vi−ui which is the residual random term composed of two elements vi and ui. The vi is a symmetric component and permits a random variation in output due to factors such as weather, omitted variables and other exogenous shocks.

Selection of the functional form is another issue surrounding parametric frontiers. Among the possible algebraic forms, Cobb–Douglas and the translog functions have been the most widely used functional forms in most empirical production analysis studies. Each functional form has its own advantage and limitations. Some researchers argue that Cobb–Douglas functional form has advantages over the other functional forms in that it provides a comparison between adequate fit of the data and computational feasibility. It is also convenient in interpreting elasticity of production, and it is very parsimonious with respect to degrees of freedom. So, it is widely used in the frontier production function studies. In addition, due to its simplicity features, the Cobb– Douglas functional form has been commonly used in most empirical estimation of frontier models. This simplicity, however, is associated with some restrictive features in that it assumes constant elasticity, constant returns to scale for all firms/farms and elasticity of substitution are equal to one [6]. In addition, the Cobb–Douglas functional form is also convenient in interpreting elasticity of production and it is very parsimonious with respect to degrees of freedom. Therefore, that is why Cobb–Douglas functional form was used in this study.

The technical efficiency of potato production in Welmera woreda was measured by considering the output obtained per household head as the dependent variable. The output of potato from the 2019/20 G. C production year was measured in quintals. The independent variables are the inputs (factors) of production used in the same production year. Accordingly, the relevant inputs which are considered are as follows:

Y = the total amount of potato produced in quintals by the i^{th} farmer;

X_1 = the total number of oxen power used for potato production in oxen-days by the i^{th} farmer;

X_2 = the total amount of labor in man-days used for potato production by the i^{th} farmer;

X_3 = the total quantity of potato seed in kilogram used for production by the i^{th} farmer;

X_4 = the total amount of chemical fertilizer in kilogram applied for potato production by the i^{th} farmer;

X_5 = the total area of land covered by potato in hectares of the i^{th} farmer;

X_6 = the total amount of organic fertilizer measured in quintals used by the i^{th} farmer and

X_7 = the total amount of agrochemicals measured in liters used by the i^{th} farmer

The Cobb–Douglas functional form of stochastic frontier production is stated as follows:

$$\ln Y = \beta 0 + \sum_{j=1}^{5} \beta j \ln Xij + Vi - Ui \qquad (14)$$

where for ith farmer, Y is the total quantity of potato produced, x is the quantity of input j used in the production process including oxen power, human labor, land, quantity of seed, amount of chemical fertilizer, amount of agrochemicals, amount of organic fertilizers, Vj is the two-sided error term and Uj is the one-sided error term (technical inefficiency effects).

The inefficiency model is estimated using the equation given below.

$$\ln Y = \delta 0 + \sum_{n=1}^{15} \delta nZni \quad (15)$$

Technical efficiency an individual potato producer will respectively be:

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{f(x_{i;\beta}).\exp(v_i - u_i)}{f(x_{i;\beta}).\exp(v_i)} \quad (16)$$

$$= \text{Actual otputdivide by Frontier output)}$$

Since the value of the observed output is less than that of the frontier output, Technical Efficiency takes values between 0 and 1. Values nearer to 1 imply better production while those nearer to 0 imply poor production or technical efficiency.

To identify factors influencing the level of technical efficiency of potato production in the study are, Tobit regression model was preferred since technical efficiency of production ranges between 0 and 1. The model specification following Greene is as [11]:

$$y^* = X_{iK}\beta + \varepsilon \quad (17)$$

Where;

$\varepsilon_{i \sim N(0,\delta^2)}$. y^* is a latent variable that is observed for values greater than Γ and censored otherwise.

The log-likelihood function for the Tobit model is:

$$lnL = \sum_{i=1}^{N} \left\{ d_i \left(-ln\sigma + ln\phi \left(\frac{y_{i-}X_{i\beta}}{\sigma} \right) \right) + \left(1 - d_i ln\left[1 - \phi\left(\frac{X_i\beta}{\sigma}\right)\right)\right\} \quad (18)$$

The overall log-likelihood is made up of two parts. The first part corresponds to the classical regression for the uncensored observations, while the second part corresponds to the relevant probabilities that an observation is censored.

Expected value of the latent variable y^*:

$$E[y^*] = X_i\beta \quad (19)$$

Marginal effect on the latent dependent variable, y^*:

$$\frac{\partial \mathrm{E}[y*]}{\partial Xk} = \beta_k \quad (20)$$

The reported Tobit coefficients indicate how a one-unit change in an independent variable X_k alters the latent dependent variable. the independent variables of the study are

X_{i1} = Age of the household head (in years);

X_{i2} = sex of the household (a dummy variable and it takes a value of 1 if male, 0 otherwise);

X_{i3} = family size (total numbers of family member who lives in one roof);

X_{i4} = education (number of years of schooling of the farmer);

X_{i5} = land fragmentation (in number of plots),

X_{i6} = Farming experience (in years);

X_{i7}=Access to (cooperative) of potato producers (dummy variable with value of 1 if yes and 0 if no)**;**

X_{i8} = Access to working in group (Debo) (dummy variable 1 if yes and 0 if no);

X_{i9} = Marital status s dummy variable 1 if married and 0 otherwise;

X_{i10} = number of livestock measured by TLU;

X_{i11} = participation in off/ non-farm activities (dummy variable);

X_{i12} = Frequency of agronomic practice training (number of training sessions attended);

X_{i13} = Frequency of extension contact (number of times visited by extension agents);

X_{i14}= Access to credit/loan;

X_{i15} = Frequency of weeding/hoeing practice

4. Results and Discussions

In this chapter, the results and discussion of the study were discussed in two sub-sections. The first section presents the descriptive results and the second section deals with econometric results from the stochastic frontier function and Tobit models.

4.1. Descriptive Results

Before discussing results obtained from the econometric models, it is important to briefly present demographic, socio-economic, farm and institutional characteristics of the sampled farmers in the study area, since they affect the quality of the management of the farmer directly or indirectly and are believed to have effect on efficiency of production [6]. In addition, it would help to draw a general picture about the study area and sampled households.

Age of the sample households heads: Age is among the key factors determining the technical efficiency and productivity of potato farmers. The age distribution of the interviewed household heads was found to be with mean of about 43 years, a minimum of 25 years and maximum a 66 years as shown in the (Table 1) below. This indicates that the majority of the sampled potato producers in the study area is at productive age and expected to produce more if scientifically supported.

Family size: Family size is among the factors in determining the level of technical efficiency of the farming household. This is manifested in the sense that large family size might create access to large family labor in undertaking farming activities. On the other hand, large family size might lead to low level of per-capita income at the household level because of sharing of household earned income among the family members which in turn might affect production efficiency. The survey result indicated that average family size of the sampled households is about 6.46, with minimum of 1 and a maximum of 12 (see Table 1). This average amount is close to the national average family size which is 6 per household.

Years of farming experience: Years of farming experience is decisive in helping farmers build skills, experiences/practices, and better farm management methods. This survey pointed out that the average/mean farming experience of the sampled households is about 21 years with minimum of 7 years and maximum of 42 years (see Table 1). This implies that the sampled farming households are rich in farming experiences.

Livestock holding size of the respondents: It is obvious that livestock is the very basic asset of the rural farming community of the study area in particular and in the country in general. Livestock are important livelihoods and means and sources of income for the rural community. The size of livestock a certain smallholder farmer owns has a direct impact on productivity and efficiency of its production. In the study area, as revealed by the survey result, the respondent households owned a mean livestock size of 11.52 TLU with a minimum of 1.28 TLU and a maximum of 51.45 TLU (see Table 1).

Access to membership in cooperatives: Being a member of cooperative has quite a lot of social and economic benefits for rural farming households. These among others include, sharing of information, technology, access to financial services and access to agricultural inputs. All these have some sort of influence on the level of production efficiency of the households. The survey result showed that 130 (86.67%) of the target households have a membership in cooperatives in their locality while 20 (13.33%) were not members (see Table 2). In terms of years of membership, the respondent households have a membership in cooperatives for an average of 5.61 years with a minimum of 0 years and a maximum of 15 years (Table 2).

Access to/membership in work party/Debo: Working in party/group is very common practice in the study area. It is among the social practices through which the rural community helps each other and strengthens its social cohesion/bondages. This practice has a significant influence on efficiency of production by enhancing labor supply and other important inputs for agricultural activities. The survey result indicated that (see Table 2) 148 (98.67%) of the sample households have used working in party with their neighbors and/or friends in their potato production in the season under consideration while only 2 (1.33%) of them did not use it.

Table 1. *Descriptive statistics for continuous variables.*

Variable	Mean	Std. Dev.	Min	Max
Age	43.89	8.13	25	66
Family size	6.46	1.92	1	12
Years of farming experience:	20.89	7.97	7	42
Livestock holding size in TLU	11.52	6.46	1.28	51.45
Year of membership to cooperatives	5.61	3.13	0	15

Source: own computation (2020)

Table 2. *Descriptive statics of discrete variables.*

Variable	Freq.	Percent
Sex of the respondent		
Female	13	8.67
Male	137	91.33
Total	150	100
Application of chemical fertilizer		
Yes	149	99.33
No	1	0.67
Total	150	100
Application of organic fertilizer		
Yes	73	48.67
No	77	51.33
Total	150	100
Use of agro-chemicals		
Yes	145	96.67
No	5	3.33
Total	150	100
Access to membership in cooperative		
No	20	13.33
Yes	130	86.67
Total	150	100
Access to participation in work party/Dabo/Jigi		
No	2	1.33
Yes	148	98.67
Total	150	100
Participation in other income generating activities		
Yes	39	26
No	111	74
Total	150	100
Access to extension contact		
Yes	116	77.3
No	34	22.7
Total	150	100
Access to training on agronomic practice of potato over the last three years		
Yes	53	35.3
No	97	64.7
Total	150	100
Access to loan over the last 12 months		
Yes	28	18.67
No	122	81.33
Total	150	100

Source: Own computation (2020)

4.2. Estimates of the Cobb Douglas Frontier Production Function

Given the specification of Translog, the Cobb-Douglas stochastic function was selected to estimate efficiency of farmers. The dependent variable of the estimated production function was potato output (Qt) and the input variables used in the analysis were area under potato (ha), oxen (pair of oxen-days), labor (man-days in man equivalent), quantity of seed (kg), quantity of chemical fertilizer (Kg), quantity of organic fertilizer (in M^3) and quantity of agro-chemicals (in litters).

The analysis finding showed that out of the seven inputs, four of them (namely land, labor, chemical fertilizer and seed) found to be statistically significant (Table 3). Land and Seed are found to have a positive coefficients implying that an increase in the amounts of these inputs will raise potato yield. Labor was found to have a negative coefficient. This implies that the sampled households had used more than the required amounts of this input on their potato farms so that a unit increase in this inputs leads to reduction in output instead of increasing it.

Amount of seed and chemical fertilizers used are found to be statistically significant at 5% significance level while land and labor are statistically significant at 1% and 10% level of significance respectively.

In addition, land and chemical fertilizers are found to be important inputs with high coefficients of 0.801 and 0.809 respectively. This implies that at ceteris paribus, a 1 unit increase in each of these inputs will raise the potato outputs by 0.801 and 0.809 units respectively. This result is consistent with the empirical findings of previous studies [1].

The scale coefficient calculated was 1.62, indicating increasing returns to scale. This implies that there is some potential for potato producers to expand their production because they are in the stage I production area. This implies that, a 1 unit increase in all inputs proportionally would increase the total production of potato by 1.62. Therefore, an increase in all inputs by 1% would increase potato output by more than 1%.

The diagnostic statistics of inefficiency component reveals that sigma square (δ^2) is 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 0.8925 which indicates that 89.25% of total variation in farm output from the frontier is due to technical inefficiency. This implies that potato farmers in the targeted area are highly inefficient in potato production. The variation in output from its frontier level is mainly (89.25%) because of lack of efficient resources (inputs) utilization. This result is somehow close to the study results of Ahmed Kasim Dube et al. [1] who reported that the inefficiency component has highly dominated the variation of the obtained output from its frontier level with value of 94% and 85% respectively.

Table 3. *Frontier analysis of stochastic Cobb Douglas production function.*

Output	parameter	Coef.	Std. Err.
lnland	β_1	.802***	.129
lnlab	β_2	-.158*	.090
lnseed	β_3	.127**	.053
lnoxen	β_4	.223	.139
lnfert	β_5	.809**	.378
lnorgf	β_6	-.088	.068
lnagroc	β_7	-.095	.174
constant	β_0	3.49***	.603
/lnsig2v		-3.855***	.525
/lnsig2u		-1.746***	.274
sigma_v		.145	.038
sigma_u		.418	.057
sigma2		196	040
Lambda		2.871	.090
Gamma (y)		.89256	

***, **, * represents significance at 1%, 5% and 10% probability levels, respectively

Source: own computation (2020)

From the analysis output the stochastic frontier estimates of the cobb-Douglas production function will take the following form:

Lny = 3.49 +0.802ln land – 0.158 lnlab +0.127lnseed + 0.223 lnoxen + 0.809lnfert + 0.088 lnorgf – 0.095 lnAgrochem

4.3. Estimated Technical Efficiency Scores and Its Distribution

The mean TE of sample farmers was about 0.737 with a minimum level of 0.305 and the maximum level of 0.937. This means that if the average farmer in the sample was to achieve the technical efficient level of its most efficient counterpart, then the average farmer could realize 21.34% derived from (1-0.737/0.937)*100 increase in output by improving technical efficiency with existing inputs and technology. On the other hand, this value shows that, on average, farmers can increase their current output level by 26.3% without increasing the existing levels of inputs. In another way, farmers on average could decrease inputs (land, labor, fertilizer, agrochemicals, oxen, seed and organic fertilizer) by 26.3% to get the output they are currently getting if they use inputs efficiently. This result is close to empirical results other similar studies [22].

Table 4. *Estimate of TE of sample households.*

Variable	Observation	Mean	Std. Dev.	Min	Max
TE	150	0.737	.1428	0.305	0.937

Source: own computation (2020)

4.4. Determinants of Efficiency

After measuring levels of farmers' efficiency in potato production and determining the presence of efficiency variation among farmers, finding out factors that affect efficiency levels among the sampled farmers is the next most important step of this study. To see this, the technical efficiency levels derived from stochastic frontier were regressed on factors that were hypothesized to affect efficiency levels by using a two-limit Tobit model. In this study, the dependent variable is efficiency scores not inefficiency. Thus, the marginal effect should be interpreted as their effect on efficiency and not inefficiency and if one wants to use inefficiency, the sign of the marginal effect, has to be changed.

The result of the Tobit regression model showed that among the fifteen (15) hypothesized variables, eleven (11) variables (education, age, faming experience, land fragmentation, extension contact, weeding frequency, TLU, access to cooperative, access to work party/Debo, frequency of agronomic practice training, extension contact, access to loan) were found to be statistically significant in affecting the level of technical efficiency of potato production in the study area whereas four variables (sex, family size, marital status and participation in off/on farm income generating activities) found insignificant in influencing technical efficiency of potato producers in the study area (Table 5).

Age of the household head: The finding of the study shows that age affected technical efficiency of the smallholder farmers in potato production positively and significantly at 1% significance level. This implies that older farmers were more efficient than younger ones. This was probably because older farmers may have better experience in farming. Moreover, farmers at older age may better accumulate life skills to manage agricultural resources like oxen, farm tools and labor that could increase their efficiency. Older farmers might also have better access to different farming resources/tools from the relationships/bondages they might have created over years and this in turn enhances timely application of inputs and execution of agricultural activities that increase efficiency of the farmer.

The marginal effect level of the variable 'age' therefore is that, keeping all other factors constant (citrus paribus), a one-year increase in the age of the farmer would lead to an increase in a probability of the farmer to be technically efficient by 0.005. This study finding looks sound because all of the sampled households are by coincidentally with in the productive age group with mean of 43.89 years, maximum of 66 years and minimum of 25 years. Similar positive and significant effect of age of the household head on efficiency was found by the empirical study [1].

Education: As hypothesized, the study shows that education is statistically significant at 5% significance level and has a positive influence on technical efficiency of potato farmers. This is because education can improve level of understanding, wise utilization of agricultural inputs and information acquisition on agricultural practices. This in turn enhances the capacity to prioritize different circumstances and to make better decisions in the process of producing potato. In addition to this, it will help them to better adopt modern agricultural technologies/practices and be able to produce higher output using the existing recourses more efficiently. Moreover, the computed marginal effect shows that, citrus paribus, a one-year increase in school attendance of the household head increases the probability of a farmer being technically efficient by 0.029. This finding is in support of the empirical findings [22, 18].

Farming experience: Regarding years of farming experience, the study reveals that it has a positive and significant impact on technical efficiency of potato farmers at 1% level of significance. The result confirmed the hypothesis and implies that the more experienced, the more technically efficient the farmers will be. This is because in the course of experiencing/practicing, farmers might acquire more farming skills, more agronomic practice training, more access to extension services and more access to social capitals which in turn helps to be more efficient. Keeping other factors constant, a one-year increase in farming experience, increases technical efficiency of potato farmers in the study area by 0.0689. This finding supports the findings of the studies conducted by the author [22].

Land Fragmentation: The study also indicates that land fragmentation is statistically significant at 10% significance level. It has an adverse relationship with the technical efficiency level of potato farmers. When plots of farms are dispersed, it might be challenging for farmers to properly manage and use resources/agricultural inputs and time in an efficient manner. However, what matters most here is how many and how dispersed (far from each other) the plots are? Thus the larger the number of the plots and the more dispersed the they are, the less efficient the farmer will be. Hence, it might affect productivity and technical efficiency of the farmers negatively. Therefore, a unit increase in the number of plots of potato farm, would lead to a decrease in the probability of the farmer to be technically efficient by 0.023 units. This finding is in support of empirical findings [1, 17].

Weeding/hoeing frequency: In the study, weeding/hoeing frequency is found to be statistically significant at 1% level of significance and positively affecting technical efficiency level of farmers. This finding is in support of the initial hypothesis. This is because when potato farms are hoed/weeded with the required frequency and time interval, productivity and hence efficiency might be enhanced. This might help potato farms to have an increased/maximize returns/outputs to all inputs and/or efforts invested on. Given all other factors constant, an increase in hoeing/weeding of potato farms by one round would lead to an improvement in the probability of farmers being technically efficient by 0.058 units.

Livestock holding size: As hypothesized prior, livestock holding size measured in (TLU) found out in the study finding as statistically significant at 1% significance level. The relationship shows positive which means that farmers with relatively larger number of livestock has a better technical efficiency level than those with less livestock holding size. The logic is that Livestock supplements the production of crops in various ways. For example, the income obtained from selling livestock and livestock products can be invested in crop production, especially in purchase of inputs such as fertilizer, seed and labor. Livestock manure could also be used to improve fertility of land which in turn augments productivity. Livestock is also the indispensable sources of animal labor and/or drought power in potato production in activities such as ploughing and harvesting etc. Citrus paribus, an increase in the number of livestock by one TLU would lead to an increase in the probability of a farmer to be technically efficient by 0.055. This study result is inconsistence with that of the findings [1].

Access to cooperative: Access to cooperative membership as found out in the study result is statistically significant at 1% level of significance – which is in line with the initial hypothesis. It is reasonable that being a member of cooperative might pave ways to get access to financial products/services, access to various context specific social services. It also creates opportunity to access various need based agricultural inputs with affordable prices. These agricultural inputs might include chemical fertilizer, improved seeds, agrochemicals etc. Being a member of cooperatives can also create opportunity for economic and social empowerment and create access to more skills through trainings. All these have a direct impact in building capacity of farmers and hence a positive impact/effect on technical efficiency of potato producer. Citrus paribus, having a cooperative membership might raise the probability of being technically efficient by 0.084.

*Access to working party/Deb*o: The study finding confirmed the hypothesis that working in groups/work party/Debo has a positive influence on technical efficiency of the potato producer. This variable is found statistically significant at 10% level of significance. The evidence/reality behind this finding is that by working in party/group, locally called 'Jigi or Debo' especially while hoeing/weeding and harvesting potato farms, farmers can get access to sufficient agricultural inputs such as labor force, oxen power, can enhance their social bondage and can share important information on agricultural activities. This practice would also have its contributions in undertaking agricultural activities within the required time and with reasonable cost. All these factors have contributions in boosting technical efficiency of potato producers in the study area. Given all other factors kept constant, having access to work in party/Jigi can heighten the probability of being technically efficient by 0.143.

Extension contact: In support and confirmation of the hypothesis, the study finding showed that extension contact is statistically significant and has a positive influence on technical efficiency of potato famers at 1% significance level. It is very apparent that extension contact/services are very crucial for a certain farmer to be productive. Extension services are mostly important because of capacitating farmers through routine on the job and practice oriented supports. This indicates households who receive more extension contacts by extension workers appear to be more efficient than their counterparts. Furthermore, the computed marginal effect result shows that, keeping other factors not changing, a unit increase in the number of extension contact would increase the probability of a farmer being technically efficient by 0.117 units. This result is similar with the empirical findings [1, 22].

Frequency of agronomic practice training: Frequency of agronomic practice training to potato farmers in the Tobit analysis result, revealed statistically significant at 10% level of significance. This is in support of the hypothesis that the more frequent a farmer trained, the more technically efficient he/she will be. Hence, more frequently trained farmers are technically more efficient than their counterparts. The reality behind this finding is that frequency in training is important for farmers who have low educational statuses like in Ethiopia in general and in the study area in particular. It requires a continuous efforts/training for less educated and illiterate farmers well internalize and exercise modern farming practices and to achieve the intended behavioral changes. Therefore, frequency of agronomic practice training would contribute to enhance technical efficiency of potato farmers in the study area. Given that other factors are not changing, a unit increase in agronomic practice training can boost technical efficiency of a given potato farmer in the study area by 0.039 unit. This study finding is similar with the findings [22].

Access to loan: Access to loan/credit service in this study indicates statistically significant at 1% of level of significance and has a positive relationship with technical efficiency status of the farming household (Table 5). This is because when farmers got access to loan of any form, they got opportunity and capacity to invest on activities which raise their productivity and/or efficiency levels. Areas of investment could be off-farm income generating activities or purchase of more agricultural inputs etc. The marginal effect of access to credit/loan service on technical efficiency of the sampled potato farmers is 0.0648 and is statistically significant at 1% level of significance.

Table 5. *Tobit regression results of determinants of technical efficiency.*

Variables	Coef.	Std. Err.	T	P>|t|
Sex of hh	.0163	.0482	0.34	0.734
Age	.0049***	0015	3.34	0.001
Marital status	.0164	0268	0.61	0.541
Education	.0294**	0139	2.12	0.036
Family size	-.0069	.0049	-1.42	0.157
Experience	.0069***	0016	4.31	0.000
Land fragmentation	-.0226*	0133	-1.70	0.092
Frequency of weeding	.0584***	0.0166	3.52	0.001
Livestock ownership I TLU	.0055***	0.0015	3.62	0.000
Membership to cooperatives	.0847***	0.0246	3.45	0.001
Access to working party/Debo	.1438*	0.0747	1.93	0.056
Received trainings	-.0166	0.0188	- 0.88	0.378
Extension contact	.1173***	0.0270	4.34	0.000
Frequency of agronomic practice training	.0396*	0.0228	1.74	0.084
Received Loan	.0648***	.0210	3.08	0.003
Constant	.9590***	.1725	5.56	0.000

Note: *, ** and *** refers to level of significance at 10, 5 and 1% respectively.
Source: Model output (2020)

5. Summary, Conclusion and Recommendation

This study was intended to identify factors affecting technical efficiency of potato farmers in the study area. Both primary and secondary data were collected. A two stage sampling method was used to draw 150 sample respondents. Tobit regression model and stochastic production frontier model were applied for data analysis. The result of cobb-Douglass stochastic frontier analysis showed that the mean technical efficiency of the sampled households is found to be 73.7%. This implied that potato most potato producers in the study area are not operating at full technical efficiency levels. A two-limit Tobit regression model result indicated that technical efficiency is positively and significantly affected by age of the household head, education, farming experience, extension contact, weeding frequency, TLU, access to cooperative, frequency of agronomic practice training, access to work party/Debo and loan but negatively affected by land fragmentation.

Based on findings of the study the following recommendations were made.

It is obvious that education enhances the understanding and analyzing capacity of farmers especially in buying in and/or internalizing modern farming technologies/practices and for critically thinking to find solutions to farming challenges that might be encountered. Thus, it is strongly recommend that local government to further promote/strengthen formal and informal education in the rural areas. Government and the concerned bodies should also take the opportunity of the fast growing/expanding information transmission and communication means such as local radio programs, social medias and telephones to educate the farming communities. This also requires further research on how to contextualize and better utilize the fast growing social medias such as Facebook to educate farmers.

The frequency with which farmers weed/hoe their potato farms affects technical efficiency of their production. Weed management is among the key farming activity in potato production. According to the information obtained from key informant interview with Welmera woreda agricultural expert, a certain potato farm need to be averagely weeded/hoed for three terms within a production season. Hence, potato farmers needed to be supported/followed up to apply a proper weed management practices mainly by kebele level extension workers.

Being a member of cooperatives in their locality has quite a lot of importance for potato farmers. Cooperatives serve their member farmers through providing financial services, providing information on better agricultural practices and technologies, provision of capacity building trainings on various aspects etc. Thus, potato farmers need to be supported/encouraged to be a member of cooperatives in their locality. For this to happen, non-member farmers have to be convinced about the development importance of being a cooperative member – by showcasing life changes of the model farmers for instance.

Access to work party locally called as 'Dabo or Jigi' is found to have a significant and positive influence on determining technical efficiency of farmers. This is helpful to accomplish activities within the required time and with the required qualities. Apart from this, it is a good platform to strengthen social bondages/relationships and to share important information among farmers etc.

The finding of the relationship between credit and efficiency suggest that improving farmers' access to credit will improve production efficiency in potato production. The government should design strategies that will enable potato farmer's access adequate and timely credit services. This includes making credit systems suitable for the poor farmers such as making adjustments on the high interest rates, lack of collateral etc. These are the key constraints hindering farmers to access loans from formal institutions as reported by the interviewed sample households. Lenders should be encouraged/supported to give a credit with sufficient "grace" period, low interest rate and with low or no material collateral.

Frequency of agronomic practice training found to be having a significant and positive impact on technical efficiency of potato farmers. In other words, the more frequently the farmers are trained on agronomic practices of potato, the more efficient they will be than their counterparts will. This is mainly because farmers cannot come to the required level of precision by a few (one or two times) training since they are mostly less educated. Hence, the government extension program should plan for providing a repeated training on agronomic practices. The training to less educated and illiterate farmers should not be limited to an indoor type rather should focus on demonstrations and field level practices.

The result of the study indicated that extension contact has a positive and significant effect on technical efficiencies. Therefore, suitable and sufficient extension services should be provided for the farmers in the study area. This could be done by strengthening the existing trend using farmers training centers (FTC) with demonstration facilities and capacitating extension agents at community levels. The current extension service trend need to be reviewed regularly to know which aspects are going well and which are not. Detail research is also required to provide inputs for better extension service provision to farmers.

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