**Technical Efficiency of Onion Production: The Case of Smallholder Farmers in Dallo Mena District, Bale Zone, Oromia National Regional State, Ethiopia**

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**ABSTRACT:** *This study was intended to identify factors affecting t technical efficiency of onion production by smallholder farmers in Dallo-Manna district of south eastern Ethiopia using cross-sectional data obtained from 183 randomly selected farmers in 2021 production year. Both descriptive statistics and econometric models were used for data analysis. Cobb-Douglas stochastic production function was used to predict the technical efficiency of onion producing farmers. The mean of technical efficiencies of farmers in the study area was 76%. The Tobit regression model was fitted and the result indicated that technical efficiency of onion production was statistically and significantly influenced by experience of household head in onion production, education level, family size, livestock holding size, access to market information, number of weeding, training, and extension contact. While land fragmentation, access to credit service, landholding size were negatively and significantly related to technical efficiency of onion production. In general, there is a need to intervene in expanding educational sector, provision of trainings, extension services and solving the problem of land fragmentations.*

**Keywords:** Cobb-Douglas; Technical Efficiency; Frontier; parametric; Ethiopia

# INTRODUCTION

Agriculture continues to dominate the economic sectors of Ethiopia. It is the source of food and cash for those who are engaged in the sector and others (CSA, 2021). It contributes about 40% for GDP, 85% for exports earning, and 75% labor force (FFI, 2019). Despite these positive contributions, Ethiopian agriculture is extremely vulnerable to rainfed which is about 97% of food crops grown using rain fed agriculture, small-scale, traditional and of subsistent nature with limited access to technology and institutional services (IFPRI, 2016; Getachew, 2020). Moreover, it is characterized by low productivity, caused by a combination of various constraints such as demographic, socio-economic and institutional which hindrance food and nutrition security and poverty reduction (Urgessa, 2014).

In Ethiopia, vegetable crop is an important economic activity that ranged from home gardening to commercial farm owned by both public and private enterprise (ATA, 2014). It is cultivated throughout the country for many purposes (Muluneh, 2016). The farm household consumes about 73% onion of production, 23% sold to the market and 1% is used for seed (CSA, 2021). The same report shows the amount of vegetables consumption at home country is more than cereals and pulses which is 63.37% and 55.14%, respectively. The same report indicates that, from total area and crops under production, vegetable accounted for about 2% and about 1.31% of the total production in quintals, respectively. The same source also indicated that, there was an increase in total food grain production. However, this increment in output could not be attributed to improvement in productivity alone, as there was simultaneous increase in the size of cultivated land.

Onion (Allium cepa L.) is a plant belonging to the family of Alliaceae that primarily emerged in central Asia especially Turkey and Afghanistan (Dawar *et al*., 2007). In the study area, irrigation expansion has been done for rain-fed supplementation in order to achieve food self-sufficiency and food security through growing cash crops such as onion, tomato, green pea, cabbage and others. Due to better market access relative to others, availability of irrigation water and irrigable land many farmers in the study area produce vegetables more dominantly onion and tomato. During *meher*, the main cropping season, farmers in area are growing onion through rain-fed farming system. However, to the best of my knowledge, limited studies have recently been conducted on technical efficiency in onion production in the study area. Therefore, the overall objective of this study is to assess the level and identify factors affecting technical efficiency of smallholder farmers’ red onion producers in Dallo Mena district of Bale Zone, Oromia national regional state, Ethiopia.

# Literature Review

## 2.1. Efficiency of agricultural production

Productivity and efficiency are both measures of production performance. However, there is a slight difference between them. Productivity is defined as the ratio of the amount of output produced to the number of resources used. However, efficiency is the ratio of the value of output produced for the cost of inputs used. One can improve the state of technology by inventing new ploughs, pesticides, etc. This is commonly referred to as technological change and can be represented by an upward shift in the production frontier. Alternatively, one can improve farmers` education, extension service, etc. This in turn will improve production efficiency of farmers and will be represented by farmers operating closer to the existing frontier. Hence, generally; productivity growth may be achieved through either technological progress or efficiency improvement (Coelli, 1995).

## Approaches of measuring efficiency

Production efficiency is concerned with the relative performance of the process used in transforming inputs into outputs by farmer. Farmer can be increasing his/her output via increasing inputs or increasing productivity of inputs and the combination of the two. In microeconomic theory, production frontier (transformation function) describes the maximum output that may be obtained given inputs and technology. Some inputs may be varied at the discretion of the decision maker, while the other inputs are exogenously fixed, acting as constraints to the production process. Any deviation from the maximal output is considered as technical inefficiency (Coelli *et al*., 2005).

In analyzing efficiency, fitting a frontier model performs better than Ordinary Least Square (OLS) regression (Coelli and Battese (1995). This is due to two main reasons; the first one is, estimation of an average function will give a picture in the shape of technology of an average firm, while the estimation of the frontier function will be more heavily affected by best performing firm and thus reflect the technology they are using. The second one is, the frontier function represents a best practice technology against which the efficiency of firms within the industry can be measured. It is the second use of frontiers, which leads to widely application of estimating frontier functions.

As stated by Farrell (1957) efficiency can be measured using either input-oriented or output-oriented approaches. The former is the ability of a firm to produce a maximal output from a given set of inputs and the latter is the ability of a firm to use as modest inputs as possible for a given level of output. Note that, both measures will coincide when the technology exhibits constant returns to scale, but are likely to vary otherwise (Coelli and Battese, 2005).

## Empirical review

A number of demographic socioeconomic, institutional, and natural factors that influence technical efficiency of red onion. There are various studies have been done so far to explore production and technical efficiency red onion of using econometric analysis. Some of them are stated as follows;

Banani *et al.* (2013) using cobb Douglas stochastic frontier production function in Indonesia, numbers of area, seed, pesticide, and employer have significant influence on the production of red onion while experience, age, and education have significantly influenced the technical efficiency of onion producer. Similarly, Khan (2015) using the Cobb-Douglas stochastic frontier production function in Pakistan specified a mean technical efficiency level of 93.74% indicating that there exists a large potential to increase onion production. Results showed that urea, farmyard manure, irrigation, and pesticides were the major factors that influence changes in onion production while education and farm size were found to have negative and significant effects on the technical inefficiency among the onion producers.

Getahun, (2014) using the Cobb-Douglas stochastic frontier production function in Ethiopia indicate a mean technical efficiency level was 80% and 61% for irrigators and non-irrigators,
respectively. The result shows farm size, urea, fertilizer, expenditure on seed, and pesticides and tractor power in case of irrigators were found to be important factors in increasing the level of onion output. While, farm size, off/non-farm occupation, credit, training, irrigation, membership to cooperative, price perception and family size were found to be positive and significant effect on technical efficiency of red onion farmers.

Using Cobb- Douglas stochastic production frontier function in Nigeria Grema and Gashua (2014) and in Ethiopia Berhan (2015) and reports that farm size, seed, fertilizer herbicide and insecticide, and hired labor were influence onion production. Land ownership, age of household, and social responsibility has negative and significant effect on technical efficiency of red onion producers while, land fragmentation, access to market, years of experience in onion production, access to training, farm income, and field visit were found to be positive and significant at different levels of significance for technical efficiency among farm household.

According to Anyatengbey (2020) farm size, seed, labor, fertilizer, and mechanization had positive influences on technical of onion producers at varying significant levels. In addition, access to credit service, age, and water pump were found be to influence technical efficiency positively but farm size was positively related to technical inefficiency.

Maniriho (2020) Cobb-Douglas type stochastic frontier functions were specified and estimated using maximum likelihood method. Results from econometric estimations revealed that seeds and organic fertilizers are the most influential determinants of onion production, and showed that the total production cost increases with an increase in onion output increasing returns to scale in the study area. The results also pointed to the significant effect of education and household size on farm efficiencies. The mean technical efficiency is estimated at 67% implying that output can be increased substantially by 49% by eliminating inefficiencies in production. Extension contact, use of recommended dose of fertilizers and non-agricultural income significantly improve technical efficiency. Efficiency is significantly higher for owner operators and diversified farms.

Yahaya *et al.* (2019) using Cobb-Douglas stochastic frontier production function in Nigeria specified mean efficiency obtained was 83.6% indicating that there was a 16.4% opportunity for improving efficiency The result indicated that gross margin, net farm income, return on capital investment gross and operating ratio influence production efficiency of red onion. On other hand educational level, years of farming experience and access to extension service positively and significantly influenced the farmers’ efficiency. Emil (2020), family size, Experience, gender, access to extension and credit service have positive and significant effect on technical efficiency of onion producers; while age, farm size, education status has positive and significant effect on technical efficiency of onion in Somali region, Ethiopia.

##  Conceptual Framework

Technical efficiency of production is influenced by various demographic (educations level, family size, gender), socio-economics (on farm income, experience, landholding size, off/nonfarm income generating activity etc.), institutional characteristics (training, access to credit and extension service, distance to market) and others (weeding frequency). Moreover, technical inputs such as seeds, land, labor, oxen, and inorganic fertilizer are combined to produce the onion output in turn affect technical efficiency of red onion.

These technical inputs and characteristics of farmer, resource endowment factor, and institutional factor with the presence of technical efficiency determine the quantity and quality of output produced smallholder farmers by considering other external factors remain constant. These factors can be representing through finger like as follow next.

 Farm characteristics

, Farm size, weeding

Plot distance

Irrigation use

Weeding frequency

Social -economic

Characteristic

Education level, Farm income, Fragmentation, Off/non-farm activity

Institutional characteristics

Frequency extension visit**,** taking training,

credit service, market information

Demographic Characteristics

* Age,
* Gender,
* Family size

Technical efficiency

Figure 1: conceptual framework of technical efficiency of onion

Source: own design-based literature review

# RESEARCH METHODOLOGY

## 3.1. Description of the study area

Dallo Mena is one the district of Bale Zone Oromia national regional state that located southeast about 555 km from Addis Ababa and 110 km away from Robe administration town of Bale zone. As the 2014-2017 Ethiopian population projection reports show, the total population of the district was about 108,930 of whom 55,193 were men and 53737 were women, and 14930 (13.70%) of its population were urban dwellers and 94000 (86.30%) were rural dwellers.

Topographically, most of this woreda is less than 1500 meters above sea level; mount Orbo is the highest point. The district has various rivers include the Welmel, Demal, Yadot, Elgo, Erba, Shawe and the Dayyu Rivers. The district lying between 5˚91' to 6˚71'N latitude and 39˚87' to 40˚26'E longitude. The district has an altitude that ranges from 1600 to 2776 meter above sea level.

## Data Types and sources

Primary data was collected through face-to-face interview using structure questionnaire.

##  Sampling Technique and Sample Size Determination

Two stage sampling method was applied to select representative sample respondents from the total population. First, from the district 14 *kebeles were identified as potential onion production and existence of irrigation. In the second stage,* three onion producers’ *kebeles* were identified and selected purposively. Finally, sample size was determined by Kothari (2004) sample size formula as follows;

Where: n is sample size; p is proportion of the population participating in onion production from total households exist in the district, q = 1-p is number of the population who do not producer onion in the district, Z = 1.96, e = acceptable error which is 6%. Based on information obtained from bureau of agriculture of the district, in this study the proportion of onion producer is 0.22.

## Methods of Data Analysis

To analyze the collected data and address objectives of the study, descriptive and econometric methods were employed.

Among econometric models’ stochastic production frontier model (SPF) and a Tobit regression model was applied.

 **Measurement Technical Efficiency**

To address objectives of the study, SPF model was selected for its key features that the disturbance variable is composed of two components, a symmetric disturbance and a non-negative. Symmetric parts that capture exogenous shocks and statistical noise (such as measurement error, topography, and weather), which are uncontrolled and exogenous to the farmer contained in every empirical relationship, particularly those based on cross-sectional household survey data. The one-sided component captures deviations from the frontier due to inefficiency. A number of recent literatures shows that many productions efficiency studies have used stochastic production frontier model to estimate technical efficiency (Jema, 2008; Grema and Gashua, 2014; Berhan, 2015; Jamal, 2020 and others).

To estimate the level of efficiency (technical efficiency in this case) the stochastic production frontier model needs a priori specification of the production function such as Cobb Douglas, trans- log functions, and others. In most of empirical study of agricultural production analysis, Cobb Douglas and trans- log functions were the most popularly used models from existing production functions. Some researcher argues 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.

In addition, the Cobb-Douglas production function is attractive due to its simplicity and because of the logarithmic nature of the production function, that makes econometric estimation of the parameters a simple matter. Trans-log production function is more complicated to estimate the parameters having serious estimation problems. One of the estimation problems is as the number of variable inputs increases, the number of parameters to be estimated increases rapidly. Another problem is the additional terms require cross products of input variables, thus making a serious multicollinearity problem (Coelli, 1995). Moreover, the majority of empirical studies done on efficiency in Ethiopia analyzed using Cobb Douglas frontier function.................

Thus, Cobb-Douglas frontier function was selected for this study. It was specified as follows:

Based on our cross-sectional framework, the linearized Cobb-Douglas stochastic production frontier model is written as follows.

Where, ln represent the natural logarithm of base e; j donates the number of inputs used; i donates the ith sample farmer; Qi represent the actual onion output of the ith sample farmer; Xji denotes jth farm input variables was used in onion production of the ith farmer; βo donate intercept and βi is vector of unknown parameters to be estimated which represent elasticity of production; Ɛi is a composed disturbance term made up of two error elements (Vi and Ui);the symmetric component (Vi) is assumed to be independently and identically distributed as random errors with zero mean and variance N(0 ,) which captures inefficiency as a result of factors beyond control of farmers and Ui proposed to capture inefficiency effects in the production of onion.

This equation (linearized Cobb-Douglas stochastic production function) is estimated by maximum likelihood method. This is because unlike other estimation methods (mostly distribution-free method), it helps us to differentiate inefficiency from statistical error.

A proviso to applying this technique is that we assume a particular distribution for the inefficiency component (*Ui*). There are distributions include the Half-Normal of *Ui* ~ *N* (0, *σ*2*u*) (Aigner *et al*. 1977), the exponential distribution of Meeusen and van den Broeck (1977), the Truncated-Normal *u* ~ *N*+ (*μ*, *σ*2 *u*) and the Gamma distribution. A likelihood ratio (LR) test is used in this study to choose between the half-normal and the truncated-normal distribution.

Given the independence assumption between *u* and *v,* we use the lambda parameterization of Aigner *et al*. (1977) and The technical efficiency of an individual onion producing farm household in the study area is defined in terms of the actual output (Qi) to the corresponding frontier (potential) output (Qi\*) given the available technology. It is computed using the following formula;

In this study technical efficiency estimate was derived from stochastic production frontier is regressed using a censored Tobit model on farm specific explanatory variables that explain variation in efficiency across farms. The rationale behind using a Tobit model is that there are a number of farm units for which efficiency could be 1 and the bounded nature of efficiency between 0 and 1.

Estimation with (OLS) regression of the efficiency score would lead to a biased parameter estimated since OLS regression assumes normal and homoscedastic distribution of the disturbance and the dependent variable. OLS underestimates the true result of the parameters by reducing slope (Greene, 2003). If the distribution of the estimated efficiencies is censored from above at the value 1, we use Tobit regression model (Tobin, 1958). So, in this study, Tobit regression model will be used, which is specified as:

ere: latent variable representing the efficiency score of farm z (technical efficiency); intercept; unknown parameter; Xki are demographic, institutional, socio-economic and farm-related variables which are expected to influence technical efficiency of onion producer; k is a number of independent variables that affect technical efficiency and Ui is an error term that is independently and normally distributed with mean zero and variance σ2.

To find out what factors determine the level of technical of smallholder onion producing households, probit and logit models can be used. In logit and probit models, the dependent variables are usually binary (Maddala, 2005).

However, when the dependent variable is roughly continuous over strictly positive values but is zero for a nontrivial fraction of the population we usually use the Tobit model.

If we run the data using linear model we would possibly obtain negative fitted values, which leads to negative predictions for mean technical efficiency; this is analogous to the problems with the linear probability models(LPM) for binary outcomes.

Using LPM for estimation resulted in violation of classical assumption of homoscedasticity.

Further, it is often useful to have an estimate of the entire distribution of the dependent variable given the explanatory variables using Tobit model.

Following Green (2005), Tobit regression model is formulated as.

 if  and 

Where

* Yi is the level of technical efficiency score of households estimated from Stochastic frontier analysis ,
* βi is the vector of parameters
* X’ is matrix of explanatory variables consists of household head characteristics, household level characteristics, and access to different institutions.
* The unconditional expectation of Y given X is

 

* The marginal effect or the effect of a change in the kth explanatory variable on the expectation of Yi given Xi with respect to X is

  

We use marginal effect which helps to determine the effect of individual variable effect.

# RESULTS AND DISCUSSION

## Descriptive and Inferential Analysis Results

**Sample household characteristics for continuous variables**

The average age of the sample household heads were 40.52 years with a maximum of 79 and minimum of 21 years. The average family size for the sample households were about 5.71 member that was lower than the national average of agricultural household size 5.2 persons per household. The average experience in onion production of the sample household heads was 8.05 years with minimum of 2 and maximum of 20 years. The average formal year of schooling of the sample household heads were 2.78 grades with a minimum of 0 and maximum of 12 grades. The average of on farm income for sample household heads was 110250.9 birr with a minimum of 2500 and maximum of 756000 birr. The average landholding size of sample household heads was 2.78 hectares with minimum of 1 and a maximum of 7 hectares.

The average livestock holding size of sample household heads were 6.27 in tropical livestock unit with a minimum of 1 and a maximum of 6.45 in tropical livestock unit. The number of a training taken by household heads was 2 on average and ranging from taking of any training to 6 times. The average distance of onion plot from Homestead of sampled households were 40.64 walking in minutes with a minimum of 12 and a minimum of 132 walking in minutes. The average land fragmented of the sampled household was 2.5 plots with a minimum of 1 and a maximum of 6 plots. The number of extensions contact by sample households 11.96 on average and ranging from 4 to 21 visit. The average number of weeding of the sample household heads was 2.71 times with a minimum of 1 and a maximum of 6 times.

Table 1: Sample household characteristics for continues variables

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variables  | Obs. | Mean | Std. Dev. | Min. | Max.  |
| Age of household  | 183 | 40.52 | 12.400 | 21 | 79 |
| Family size of household | 183 | 5.71 | 3.29 | 1 | 14 |
| Experience in onion production | 183 | 8.049 | 4.204 | 2 | 20 |
| Formal year of schooling  | 183 | 2.776 | 3.042 | 0 | 12 |
| On farm income | 183 | 110250.9  |  98761.76 | 2500 | 756000 |
| Landholding size | 183 | 2.778 | 1.252 | 1 | 7 |
| Livestock-holding size  | 183 | 6.517 | 3.553 | 1 | 6.45 |
| Frequency of taking training | 183 | 2.00 | 1.822 | 0 | 6 |
| Distance of onion plot from Homestead | 183 | 40.639 | 23.960 | 12 | 132 |
| Land fragmentation | 183 | 2.546 | 1.118 | 1 | 6 |
| Frequency extension contacts  | 183 | 11.945 | 6.367609 | 4 | 21 |
| Number of weeding  | 183 | 2.705 | 1.47519 | 1 | 6 |

Source: Own computation from survey data (2021)

**Sample household characteristics for dummy variables**

As survey results indicate, among the sampled households, about 82.51% were male-headed household and 17.49 were female-headed household in the study area. From the sample household heads, about 76.49% of the sample household heads had participated in off or non-farm activities and 23.50% of them do not participate in off/non-farm income source of activities. The survey result indicates that 54.10% of the sample households had access to irrigated water and 19.59% of them do not have access to irrigation water. From the sample, household heads 62.84% of the sample households had access to market information and 37.16% of them do not have access to market information. On other hand, 70.49% of the sample households had access to credit services and 29.51% of them do not have access to credit service.

Table 2: Sample household characteristics for dummy variables

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Category | Frequency  | Percentage (%) |
| Gender of household | Male | 151 | 82.51% |
| Female  | 17 | 17.49% |
| Off/non-farm income  | Yes  | 140 | 76.50% |
| No  | 43 | 23.50% |
| Access to irrigation water | Yes  | 99 | 54.10 % |
| No  | 84 | 45.90% |
| Access to market information  | Yes  | 115 | 62.84% |
| No  | 68 | 37.16% |
| Access to credit service  | Yes  | 129 | 70.49% |
| No  | 54 | 29.51% |

Source: Own computation from survey data (2021)

## Tobit Regression model results

Inthis subsection, the econometric results of the study such as, testing hypothesis, production functions, efficiency scores, and determinants of efficiency were presented and discussed. Before going to proceeds to econometric models’ analysis, the data was tested against various econometric problems. Firstly, hetroscedasticity was assumed and robust- hetroscedasticity was applied to made coefficient of parameter more efficient. Secondly, multicollinearity test for independent variables was done using Variance Inflation Factor (VIF). Test for multicollinearity was made using Stata 15 software for the values of variance inflation factor for both input and inefficiency variables. There is no serious linear correlation among explanatory variables, since the values of VIF are less than 10 (Appendices 3and 4).

### 4.2.1. Test of Hypothesis

Unlike non-parametric models (DEA), parameter models including SPF model, it is possible to test various hypotheses using maximum likelihood ratio test. Thus, in SPF model there are three hypotheses testing as follows:

**First hypothesis testing** was testing whether Cobb-Douglas production function fits the data at hand for onion production in the study area or not. The functional form that can better fit to the data at hand was selected by testing the null-hypothesis that the coefficients of all interaction terms and square specifications in the trans-log functional forms are equal to zero (H0= βij= 0). The test was made based on the value of likelihood ratio (LR) statistics which can be computed from the log likelihood values of both the Cobb-Douglas and Trans-log functional forms. Then, the value was compared with the upper 5% critical value of the χ2 at the degree of freedom equals to the difference between the numbers of explanatory variables used in both functional forms (in this case df =21). In other words, the degree of freedom is the number of interaction terms and square specifications in the trans-log case restricted to be zero in estimating the Cobb-Douglas functional form.

The log likelihood functional values of both Cobb-Douglas and Trans-log production functions were -166.11 and -142.70 respectively. The LR value computed, thus, was 32.82 and this value is lower than the upper 5% critical value of the χ2 which is 32.67 at the degrees of freedom equal to 36. As a result, the null hypothesis that all coefficients of the interaction terms in Trans-log specification are equal to zero was not rejected. This implies that the Cobb-Douglas functional form adequately represents the data under consideration. Hence, the **Second hypothesis** was testing for the existence of the inefficiency component of the total error term of the stochastic production function. In other words, we have to decide whether the average production function (without considering the non-negative random error term) best fits the data. Computing the likelihood ratio (LR) from the log likelihood functions of both the average response function and the stochastic production function, we can perform the test for the null hypothesis that the inefficiency component of the total error term of the stochastic frontier specification equals to zero (γ = 0) against the alternative hypothesis that inefficiency component is greater than zero (γ> 0). If the null hypothesis is accepted, (i.e. one-sided error term is equal to zero) then the stochastic model is identical to the average response function indicating that there is no inefficiency problems within potato producing farmers. The likelihood ratio statistic computed (using one-sided generalized likelihood ratio test of γ= 0) from the values of log likelihood functions under both the average response function and full frontier function given the specification of the Cobb-Douglas production function was 142.70. The value is much higher than the χ2 critical value for the upper 5% which is 3.84 at one degree of freedom. The greater computed LR value reveals the existence of inefficiency or one-sided error component in the model. Hence, the hypothesis that potato producers in the study area are technically efficient is strongly rejected. As a result, the production behavior of potato producers in the study area can better be represented by the stochastic production function than the average response function.

**The final hypothesis tested** was that the null hypothesis that the explanatory variables associated with technical inefficiency effects are all zero, (H0: ui=δ0 = δ1 = δ2 - - - δ17 = 0). To test this hypothesis likewise, λ (The inefficiency effect) was calculated using the value of the log-likelihood function under the stochastic production frontier model (a model without explanatory variables of inefficiency effects, H0) and the full frontier model (a model with variables that are presumed to determine inefficiency of each farmer, H1)

The calculated value of 41.25 is greater than χ2 critical value of 27.587 at 17 degrees of freedom. This implying that the null hypothesis that variables in the inefficiency effect in the stochastic frontier model are simultaneously equal to zero was rejected at the upper 5% significance level. Therefore, the explanatory variables associated with inefficiency effects model are simultaneously different from zero. Hence, these variables simultaneously explain the difference in inefficiency among farmers.

Table 3: Hypothesis testing

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Null hypothesis | DF | LR | χ2-Valu | Decision rule |
| H0: β8=β9….......β44=0 | 36 | 46.82 | 50.998 | Accepted |
| H0: γ=0 | 1 | 142.70 | 3.841 | Rejected |
| H0: λ=δ1=...... δ17= 0 | 17 | 41.25 | 27.587 | Rejected |

Source: own computation from survey, 2021

### 4.2.2. Stochastic production frontier model Results

As concluded in the hypothesis test, the Cobb-Douglas functional form of the stochastic frontier model with half-normal distributional assumption of the error terms is selected to estimate the parameters of the model. The Parameters were estimated simultaneously with those involved in the model for the inefficiency effects. The coefficients of Cobb Douglas production function for input variables were interpreted as elasticity of production.

The estimated stochastic production frontier model indicated that input variables such as land size, inorganic fertilizer (Urea and DAP), organic fertilizer (compost and manure), human labor, oxen power and Agro-chemicals (herbicides or pesticides) found to be positive and significant effect on onion output at 1% probability level in the study area. While quantity of seed used in kilogram was negative and significant effect on onion output at 1% significant level. The positive elasticity of inputs implies any intervention that improves the use of that input would give significant improvement in potato output while negative coefficient of input lower output of onion.

**Elasticity of onion production:** The coefficient production inputs that included in the model was sum to 1.88 which indicating that the 1% increase in inputs simultaneously leads to 1.88% increment of onion production. On other hand, the sum of input coefficients is greater than one which indicates onion production scores was increasing returns to scale in the study area. This has consistency with the result of Debertin, 2012 and (Maniriho *et al*., 2020).

Table 4: Maximum likelihood estimates of the Cobb-Douglas SPF with efficiency model

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| lnQONION | Coefficient  | Std. Dev.  | t-Value  | p>|t|-Value  |
| LnDAP | 0.2967 | 0.0804 | 3.69 | 0.000\*\*\* |
| LnUREA | 0.0359 | 0.0708 | 0.51 | 0.613 |
| LnLABOR | 0.6083 | 0.1277 | 4.76 | 0.000\*\*\* |
| lnSEED  | -0.3161 | 0.1282 | -2.47 | 0.014\*\*\* |
| lnOXPOWER | 0.4693 | 0.1067 | 4.44 | 0.000\*\*\* |
| LnORGFRT | 0.2365 | 0.0697 | 3.39 | 0.001\*\*\* |
| lnPLAND  | 0.2521 | 0.0599 | 4.21 | 0.000\*\*\* |
| LnCHEMI | 0.3004 | 0.1107 | 2.71 | 0.007\*\*\* |
| Cons.  | -0.5130 | 0.7902 | -0.65 | 0.840 |
| Elasticity  | 1.88 |  |  |  |
| Wald chi2(8)  | 425.30 |  |  |  |
| Sigma\_v  | .5997426 | .0314474  |  |  |
| Sigma\_u  | .0092925 | .4380804 |  |  |
| Sigma-squared ( 2) | .3597775 | .0379643 |
| Lambda (λ) | .0154942 | .4416444 |
| Log-likelihood function | -166.11 |  |  |  |
| Sample  | 183 |  |  |  |

\*, \*\*, \*\*\*, significant at 10%, 5% and 1%, significance level, respectively

Source: Own computation from survey data (2021)

### 4.2.3. Technical Efficiency Scores

The first objective of this study was to measure the level of technical efficiency for smallholder onion producer farmers. The estimation result indicates that the mean levels of technical efficiency of sample households was 0.76, which reveals existence of a possibility to increase the level of onion output by about 24% by efficient use of the existing resources. On other hand, 24% of the onion output are lost due to inefficiency of farmers. The mean levels of efficiencies are comparable with the results from other similar studies in different countries. For instance, Banani *et al*. (2013) found the mean technical efficiency of red onion farming in Brebes Regency Indonesia to be 80%, Getahun 2014 found mean efficiency levels onion farmers in east Shewa zone Ethiopia to be 78%.

Table 5:Technical efficiency score

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable  | Mean  | Std. Dev. | Minimum  | Maximum  |
| Technical efficiency score | 76.00 | 0.18 | 0.28 | 0.99 |

Source: Own computation from survey data (2021)

### 4.2.5. Determinants of technical efficiency in onion production among smallholder farmers

After measuring the level of technical, efficiency scores, it was important to identify the source of inefficiency among smallholder farmer in onion production. The result of Tobit model showed that among the seventeen variables including in the model ten variables (experience of household in onion production, education level, family size, landholding size, on farm income, livestock holding size, frequency of extension contact and taking training) were found to be statistically significant in affecting the level of technical efficiency. The results on the determinants of technical efficiency of onion production are presented on Table 13.

**Experience in onion production:** The model resultindicates that experience in onion production was positive and significant effect as expected on technical efficiency of onion producer farmer in the study area. As experience in onion production of household head increase by one year, the technical efficiency of onion producer farmer increases by 0.47% keeping other factors constant. This could be; because experience is a proxy for managerial aspects and improves the skill and technical capacity that enables to best match inputs and in cost saving aspect so attain higher productivity at minimum cost. On other hand, the relationship implied that, there is an increase in technical efficiency by 0.47%, as one’s experience increases by one year.

**Family size:** As the model result shows family member has positive and significant effect on technical efficiency of onion producing farmers at 1% level of significance. As family size of household increases by one-man equivalent, the technical efficiency increases by 0.68% score keeping other factors remain constant. This result implies that an increase in the number of family members could increase technical efficiency of household in the study area This is due to the fact that, family labor is the main input in crop production and household with more members can perform farming activities effectively and efficiency since crop production in Ethiopia is labor-intensive activity. This result similar with the result of Jemal (2020) and Maniriho *et al.* (2020) reports the contribution of more family labor in farm activity was important in managing in proper allocation of factors of production optimally.

**Education of household head:** The estimated result indicates education level of household head was positive and significant effect on technical efficiency of red onion producing farmers at 1% significant level. This implies that as education level of household heads increases by 1 level of grade, the technical efficiency of onion increases by 1.2% score keeping other factors remain constant. The possible reason is that education enhances their managerial skill, better access to information and good farm planning. On other hand, farmers that are more educated have better ability to manage their farm resources and agricultural activities and willing to adopt improved production technologies than less educated and illiterate. This positive effect of education on technical efficiency is in line with existing literature that proved positive association of formal year education on efficiency. For instance, (Getahun, 2014; Akkamiin *et al.,* 2017; Maniriho *et al.* 2020), access to better education enables households to better manage their resources in order to sustain the environment and produce at optimum levels.

**Landholding size*:***As model, result indicateslandholding size has negatives and significant effect as expected on technical efficiency of onion producing farmers at 10% significant level in study areas. This reveals that as landholding size of household head increase by one hectare, the technical efficiency of onion producing farmers increase by 1.19%. This is because; small land size is expected to be more efficient than large farm because of its simplicity in management and transaction costs. The result indicated that the size of land cultivated by red pepper farmers increases; technical efficiency level of red pepper production decreases. This can be explained by the fact that increased farm size diminishes the appropriateness (timeliness) of input use leading to decline in technical efficiency. Alternatively, as the farm size increases the managing ability of the farmer decreases given the level of technology which adversely affects technical efficiency. In other words, it might be because farmers have limited supply of labor especially during the peak time of red pepper transplantation and red pepper is labor-intensive crop (this led to poor management with increase in farm size). Availability of large amount of timely financial resources at large farms could be another constraint; therefore, big farm size is finally resulting in higher technical inefficiency. This result is in line with the

**Livestock holding size:** Number of livestock holding size by households’ head in terms of TLU has positive and significant on technical efficiency of onion producing farmers. This implies that as livestock holding size increase by 1in TLU, the technical efficiency of onion producing farmers. This means households who have large livestock holding size were more efficient than small holding size. this is because, livestock in a crop-livestock mixed farming system have various advantage such as it supplies oxen power for ploughing land, provide manure and compost that will be used to maintain soil fertility and it serves as shock absorber to an unexpected hazard in crop failure as sources of food and income (cash) for the family. Timely ploughing and threshing is decisive in the production of crops thus access of livestock is important to better production. Since all types of animals and poultry production are considered in this study, livestock competitive effect has dominated its supplementary effect.

Table 6: maximum likelihood estimation of the efficiency effect model

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables  | Coefficient  | Std. Err.  | t-value  | P>|t|- value  |
| AGEH | -0.0010 | 0.0008 | -1.35 | 0.180  |
| EXPOP | 0.0047 | 0.0021 | 2.28\*\* | 0.024  |
| GENDHH | 0.0269 | 0.0194 | 1.39 | 0.168 |
| FAMSIZE | .0068 | 0.0028 | 2.40\*\*\* | 0.018 |
| DSTOPH | -9.9 e-04 | 4.3e-04 |  -0.21 | 0.833 |
| LANDHS | -0.0119 | 0.0065 | -1.82\*  | 0.070 |
| TLU | 0.0043 | 0.0025 | 1.69\* | 0.093 |
| OFNINCO |  0.0103 | 0.0174 | 0.59 | 0.556 |
| EDUCLHH  | 0.0120 | 0.0034 | 3.50\*\*\* | 0.001 |
| FRTTRN  |  0.0093 | 0.0055 | 1.69\*  | 0.094 |
| ACCTS  | -0.0277 | 0.0166 | -1.67\* | 0.097 |
| ACIRWR | -0.0140 | 0.0172  | -0.82  | 0.415 |
|  FREXC | 0.0185 | 0.0028 | 6.52\*\*\* | 0.000 |
| ACCMRI | 0.0608  | 0.0152 | 4.00\*\*\* | 0.000 |
| FINCOM |  -8.31e-08  | 8.06e-08 | -1.03  | 0.028 |
| LANFRG | -0.0277 | 0.0077 | -3.62\*\*\*  | 0.000 |
| NWD | 0.0144  | 0.0073 | 1.96\*\* | 0.051 |
| Cons.  | 0.4762  | 0.0602 | 7.90 | 0.000 |

Source: Own computation from survey data (2021)

**Frequency of extension contact:** The coefficient for the frequency of extension contact has statistically significant positive relationship with technical efficiency at 10 percent. The positive estimated coefficient for contact with extension workers implies that efficiency increases by 0.262 scores keeping other factors constant with as the number of visits made to the farm household by extension workers increase by one at a production period. Advisory service rendered to the farmers in general can help farmers to improve their average performance in the overall farming operation as the service widens the household’s knowledge with regard to the use of improved agricultural inputs and agricultural technologies. However, the negative coefficient of extension contact which is significant in AE indicates that efficiencies in resource allocation are deteriorating by 0.24 score as the frequency of extension contact increases by one keeping other factors constant. This may be because; as most farmers explained during the survey that they do not have new skills and information, they learn from development agents about allocating resources at cost saving way. There were development agents who agree with the farmers concern. If this is the case, the contact with extension agent will only result in under-utilization of resources, giving a negative relationship with allocative efficiency. Jude et al. (2011) and Mustafa (2014) obtained similar results.

**Frequency of taking training**: The result shows that frequency of taking training by household head was found to be positively and significantly influence technical efficiency of onion producer farmers in the study area. As frequency of taking training by household head increase by one time, the technical efficiency of onion producing farmers decrease by 0.93% keeping other factors constant. This could be related to the advantage of getting technical knowledge and skills related to honey production because of training. That means giving training has a positive impact on technical efficiency of the onion farmers. This positive relationship seems to support the already started program to train farmers for relatively longer periods. A number of farmers‟ training centers have already been constructed to train farmers for a given period of time even though they are not fully functional because of different reasons. In addition to the estimation of the inefficiency effects model, a simple

**Access to marketing information:** As the model, result shows access to market information by household head was found to be positively and significantly influence as expected on technical efficiency of onion producer farmers. As access to market information increase of household head by 1%, technical efficiency of onion producer farmer increases by 6.08%. This implies the better information farmers have the more efficient utilization of inputs which in turn increases the technical efficiency of red onion production. On other hand, maintaining a competitive advantage requires a sound business plan which means producing optimum red onion.

**Access to Credit service:**  the result shows that access to credit service has negative and significant which was unexpected results on technical efficiency of onion producing farmers. This reveals that as access to credit service of household head increase by 1%, the technical efficiency of onion producing farmers decrease by 2.77% keeping other factors constant. As most farmers explained during the survey that they did not apply full package program, that is using improved seed and DAP with urea for increasing production by efficient allocation of resources at recommended rate in cost saving way. This may be because of fearing repayment which did not consider risk, weather condition changing and non-existence of agricultural insurance.

**Land fragmentation:** The model result shows that number of land fragmentation was found to be negative and significant effect on technical efficiency of onion producer farmers at 1% significant level in the study area. The result indicated that a farmer with a greater number of red pepper plots is more technical efficient than a farmer with a smaller number of onion plots. The reason is perhaps as the number of plots operated by the farmer increases; the farmer will be able to distribute labor resources for different activities. Moreover, it might be used as one of the risk minimization strategies of farmers. Farmers may be benefited from fragmented red onion plots in that different plots may represent the reduced risk that different plots provide if the plots are located sufficiently distributed, such that farmers face different degrees of weather-induced variations such as floods and mineral content on the different plots.

**Number of weeding:** the model result indicates that number of weeding by household head was found to be positive and significant effect as expected on technical efficiency of onion producer farmers. This indicating that there is a positive relationship between onion productivity per hectare and the number of times weeding is repeated on a given plot. As number of weeding increases by one-time, technical efficiency of farmer increases by 1.44%. This implies that a successful cultivation of onion depends largely on the efficiency of weed control. Weed control during the first 6–8 weeks after planting is crucial, because weeds compete vigorously with the crop for nutrients and water during this period

# Conclusions and Recommendations

In Ethiopia onion, producer farmers are producing more than ever before, but the demand for the onion has consistently outpaced supply. This requires seeking for a means to increase onion productivity of smallholder farmers. In this context, the measurement of existing efficiency in onion production and identifying the determinant to seeking alternative solutions for this problem becomes paramount important. This study analyzed the level technical efficiencies and factors that explain the variation in efficiency among onion producer farmers in the district of Dallo Mena, Bale zone, Oromia national Regional State.

The study was used both primary and secondary sources of data. Primary data were collected from 183 sample households using semi-structured questionnaires. While secondary data were collected from a published and unpolished source to support primary data. The selection of the study area was purposive, and the selection of onion producing households made randomly. Descriptive statistics and econometric models were applied for data analysis. Descriptive statistics such as mean, standard deviation, percentage, frequency, and table were used. Econometric models like The Cobb-Douglas stochastic frontier production function were used to predict TE. The SFA approach was chosen as it best suits a single output and multiple-inputs production programs and as it easily disaggregates inefficiency effects in production into non-random and random error components. The survey data were analyzed using both descriptive statistics and econometric model for the estimation of efficiency and efficiency differentials.

The MLE of the stochastic Cobb-Douglas frontier production function signified important implications on factor’s contribution and productivity increase of onion in the study area. Estimation of the production frontier indicated that among the total of eight input variables considered in the production function, seven (labor, oxen power, DAP, seed, organic fertilizer and Agro-chemicals) had a significant effect in explaining the variation in onion production among farmers. These implying farmers should use the maximum possible levels of these inputs to enhance onion production. The coefficients of the Cobb-Douglas production function are interpreted as elasticity and summing the individual elasticity yields a scale elasticity of 1.88%. This indicates that farmers are facing decreasing returns to scale and hence onion production in the study area was increasing to scale. The study also indicated that 76.0% mean levels of TE. This in turn implies that farmers can increase their onion production on average by 24.0% when they were technically efficient.

Regarding to the sources of efficiencies, the study found that experience, education, family size, livestock holding size, training, extension contact, marketing information and number of weeding contributed significantly and positively to TE, while landholding size, access to credit and land fragmentation were positively and significantly influence TE.

Improving Technical efficiency of smallholder farmers is an important development strategy to achieve food and nutrition security and improve income. The following recommendations were forwarded based on the result obtained from empirical reports;

Experience in onion production has positive and significant effect on technical efficiency of onion producer farmers. This shows that more experiencing farmer in onion production was highly technical efficiency than less experiencing farmers. There is a need for experienced farmers to target onion production and share their experience for others.

Formal year of the schooling by household head has a positive and significant effect on the TE of onion producer farmers. This indicates more educated farmers have high capacity to use the resource efficiently than less educated farmers. There is a need for educated farmers to target for onion producer because their technical efficiency is high. In order to make less educated farmers also have better understanding towards onion producing and make a decision to producer more, Government, NGO, and other stockholders should give attention to strengthening different educational opportunities like informal education and training in the study area.

Landholding size of household has negative and significant effect on household participation in malt barley contract farming. This indicates that large farm size reduces the extent of household to producer onion efficiently. Thus, households who had large farm size is less efficient than who had small farm size. Thus, government and other concerned bodies should give training to households how to improve their division of labor for their farm activity, which enable them to increase productivity and diversify their agricultural production on large hectare of land thereby increase their productivity.

Number of Livestock ownerships excluding oxen in terms of TLU has positive and significant effect TE of onion producer farmers. Farmer who had a large livestock unit is found to be more efficient than those who had a small livestock unit. The implication of the result was that livestock could afford risks and serve as buffer stock during a crop, draft power, manure, and compost. Thus, in order to increase TE of a farmer, there is a need for government and any other concerned bodies to improve the existing breeding, and traditional mixed farming system in the study area.

Access to credit service has negative and significant effect on TE of onion producer farmers. This reveals that household who had access to credit service is tending to invest in the production of malt barley that meets the buyer’s or agribusiness firm’s quantity and quality requirements, which can then earn them premium prices and more income from contract. To enhance smallholder’s participation in contract farming, there is need to facilitate their access to credit services through reducing credit procedures like collateral and other credit producers and expand financial institution in rural area.

Frequency of extension contact has positive and significant on technical efficiency of onion producer farmers. Since extension services are the main instrument used in the promotion of demand for modern technologies, appropriate and adequate extension services should be provided. This could be done by designing appropriate capacity building program to encourage development agents to reduce the shifting job, Strengthen the DA education system, provide more funding to sustain quality centers, ensure provision of equipment or inputs to demonstrate best farming practices, increase coordination among institutions that deliver extensions services. The result also indicated that extension contact has negative and significant effect on allocative efficiency. This means that additional effort should be devoted to upgrade the skills and knowledge of the development agents so that farmers could gain from their presence. Such an effort should also focus on linking modern farming practice with the indigenous knowledge.

Frequency of taking training has positive and significant effect on TE of onion producer farmers. Provision of training for farmers to improve their skills in irrigation agronomy, resource management, post-harvest handling, and general farm management capabilities will increase their farm productivity. In addition to strengthening the existing extension service focusing on practical training provided to farmers, efforts should be made to train farmers for relatively longer period using the already constructed farmers‟ training centers and agriculture research demonstration centers Access to market information has positive and significant effect on technical efficiency of onion producer farmers.

Access to marketing information has positive and significant effect on TE of onion producer farmers in the study area.This implies that improving the marketing systems of onion by establishing and strengthening the onion-marketing cooperative which reduce and absorb the risk of price fluctuation is essential. If the farmers have no fear or doubt on the future output-selling price, they will be confident and encouraged in managing their farm effectively. Thus, there is a need to increase the availability market information through development agent and media like radio, TV, and newspaper by concerned body.

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