

Technical, Allocative, and Economic Efficiency of Potato Producers in Central Oromia, Ethiopia

Gadisa Muleta^{1, *}, Addisu Getahun²

¹Ethiopian Institute of Agricultural Research (EIAR), National Agricultural Biotechnology Research Center (NABRC), Holeta, Ethiopia

²Ethiopian Institute of Agricultural Research (EIAR), Holeta Agricultural Research Center (HARC), Holeta, Ethiopia

Email address:

gadisamuleta@gmail.com (G. Muleta)

*Corresponding author

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Abstract: Potato is the most important food and cash crop in mid and highlands for its potential in high yielding, good nutritional values, early maturing, improving food security, reducing poverty, serving as a main source of income for farmers, and improving the livelihood of millions of farm households, especially in developing countries like Ethiopia. Therefore, assessment of the technical, allocative, and economic efficiency of potato farmers is paramount important, and this study was intended to achieve this objective. Accordingly, primary data were collected from 301 potato-producing households from two districts, Walmara and Ejersa Lafo districts from central Oromia, Ethiopia. The stochastic frontier model of truncated normal distribution and Cobb-Douglas production function was employed, and the result revealed that households from both districts were not efficient in potato production as the mean technical, allocative, and economic efficiency scores were 61.21, 79.56, and 50.23 percent respectively, indicating the possibility that the households can increase their potato production by 38.78%, and the possibility of reducing potato production cost by 49.76%. Gender of the head and experience in potato production were the variables that positively affected households' technical efficiency, while Age of the head, the occurrence of potato diseases, and distance from institutions like farmers' training centers and cooperative unions were the variables that negatively affected households' technical efficiency in potato production.

Keywords: Technical Efficiency, Allocative Efficiency, Economic Efficiency, Stochastic Frontier, Potato, Ethiopia

1. Introduction

Agriculture remains the key economic sector in reducing poverty and boosting food security in Sub-Saharan Africa. Similarly, this sector is expected to create job opportunities for about 70 percent of the population of the country, contributing about 40 percent of the GDP of the country, feeding the ever-growing population of the country, and providing input for the infant agro-processing industries [1, 2].

Unlike its contributions, the growth of the agricultural sector remained under poor performance as of weak technology adoption, erratic rainfall and climate variabilities, political instabilities, farmers' inefficiencies, the dominance of smallholder farmers mainly using traditional farming tools, rain-dependent production system, soil erosion, and land

degradation, inappropriate land tenure, and other related problems [3, 4].

Potato is the 4th most important crop both in the area under cultivation and total production. It is one of the most important cash and food crops in mid and highlands, having a great potential of high yielding, good nutritional values, early maturing, improving household food security and income, reducing poverty and improving the livelihood of millions of farm households, especially in developing countries like Ethiopia [5, 6].

In Ethiopia, the demand for potato, the area under production, and the annual production and productivity is rapidly increasing in recent years. During the main season of 2020 and 2021, the total land under potato production raised by 22.2% (from 70,362.22 hectares in 2020 to 85,988.43 hectares in 2021), the total production of potato also raised by 23.5% (from 9,245,283.61 quintals in 2020 to

11,418,717.25 quintals in 2021), and the productivity of the crop also increased by 1.06%, from 131.4 quintals in 2020 to 132.79 quintals in 2021 [7].

Unlike the potential of the crop in improving food security, income and household livelihood, the national average of potato production in Ethiopia is very low (14 tons per hectare) compared to that of Africa (15 tons per hectare), that of the world (21 tons per hectare) and that of the top producing countries, which is 43, 37 and 29 tons per hectare for Australia, Canada and Egypt respectively [7, 8].

Biotic and abiotic factors, and production efficiency of the farm households are the major responsible factors for significant yield reduction of potato production. Therefore, this study was intended to assess technical, allocative and economic efficiency of potato farmers in central Oromia, Ethiopia.

2. Research Methods

2.1. Description of the Study Area

The study was conducted in two districts of central Oromia, Ejersa Lafo and Walmara districts. Walmara district is one of the districts under Finfinnee surrounding Oromia Special zone, Ethiopia. It is located at 34km to the west of Addis Ababa between 8°50'-9°15' N and 38°25'-38°45' E. According to Tokuma and Debissa [9], the total area of the district is about 77,119 hectares. Out of the total land, 64984 hectares were cropland, 2442 hectares were grass land, 4329 hectares were forest land, 1404 hectares were wetland, 3790 hectares were settlement areas, and 170 hectares were water bodies. The population of the district was 117,158 out of which 58,486 were males and 58,672 were females [10].

The agroecology of the district is mainly highland, and mid-highland, with a mean altitude of 2400 meters above sea level that is ranging from 2060 to 3380 meters. The annual average rainfall of the district is 1,144 mm, that ranging from 795 to 1300 mm. The average temperature of the district is 14°C, that ranging from 6°C to 24°C [11].

The district is mainly characterized by its mixed crop and livestock production similar to other central highlands of the country. Wheat, Barley, Tef, Pulses, oil seeds, and potatoes are the major crops grown in the district, and these crops are the major staple food in the district. Potatoes, cabbages, tomatoes, carrots, and onions are the major vegetable crops grown during the off-season using irrigation [11].

Ejersa Lafo district is one of the districts in West Shewa zone, Oromia regional state, Ethiopia. The district is located at 70km to the west from Addis Ababa, and 47km from Ambo, the capital town of west Shewa zone. The geographical location of the district is in between 9°0'-9°50'N and 38°30'-38°45'E. The district covers an area of 32,365 hectares, and administratively divided into 17 rural and 3 urban, totally 20 kebeles. Agroecologically, majority part of the district (74%) is classified as highland, and the rest 26% is classified as midland whose altitude is ranging 2000 to 3288 meters. The mean average temperature of the district is

19.67°C, ranging from 5.4°C to 26.4°C, and the annual rainfall also ranges from 750 to 1170mm. The farming system of the district is mainly characterized by mixed crop and livestock production and they are major sources of livelihood for the population of the district [12, 13].

2.2. Sampling Procedure and Sample Size Determination

To select the required sample districts and sample households, a multi-stage sampling procedure was employed. Walmara and Ejersa Lafo districts were purposively selected first based on their potential for potato production. Kebeles in the districts were classified into two based on the access of irrigation services at the second stage. Then, representative kebeles from both districts were randomly selected from those kebeles having irrigation access at the third stage. Accordingly, five kebeles from Walmara district and three kebeles from Ejersa Lafo district were randomly selected. Finally, a total of 301 sample households from both districts, 201 households from Walmara and 100 from Ejersa Lafo were randomly selected using systematic random sampling techniques.

2.3. Types Data and Methods of Collection

Both primary and secondary sources of data were used. Primary data were collected from sample households selected from both districts using structured and semi-structured questionnaire surveys. Secondary data were collected from different published and unpublished sources like journals articles, reports, books and web sites.

2.4. Methods of Data Analysis

2.4.1. Descriptive Data Analysis

The socio-economic, institutional and demographic factors were summarized using descriptive statistics like mean, percentage, minimum and maximum.

2.4.2. Econometric Model

Technical Efficiency: Any producer aims maximizing his profits through maximizing production and minimizing costs. But all may not succeed. Some farmers can produce more products using the same inputs compared to other farmers. These deviations from the efficient production frontier could be due to different reasons, and there are different estimation techniques like parametric, non-parametric and mathematical methods. According to Bauer, Technical efficiency can be estimated using parametric approach, which is the stochastic frontier model. This model assumes that the deviation from the efficient frontier depends on farm's inefficiency i.e., factors that can be controlled by the farmer), and the stochastic parameter i.e., those factors that are out of the control of the farmer [14].

In assessing the efficiency, econometric approach, the stochastic frontier production model is preferred in recent literatures compared to other methods like data envelopment analysis. Data envelopment analysis for example assumes all the deviations from the efficient frontier is due to farmer's

inefficiency. But variability in agricultural production may resulted from biotic and abiotic factors like climate variabilities, plant pests and diseases. Moreover, it is difficult to use data envelopment analysis as it is difficult to get accurate farm records of both input and output from small scale farmers.

The stochastic frontier model contributed much in modeling agricultural production and its efficiency. In this article, the stochastic frontier model is described following Aigner [15] and Parikh [16]. The model begins with a stochastic production function of a multiplicative error term that can be expressed as:

$$Y_i = f(X_i, \beta_i) e^{\varepsilon_i} \quad (1)$$

Where: Y_i = the maximum output,
 X_i = a vector of inputs (non-stochastic),
 β_i = unknown parameters to be estimated,
 ε_i = stochastic disturbance or error term.

Taking the natural logarithm of equation 1 (the Cobb-Douglas),

$$\ln Y_i = \beta_0 + \sum_{j=1}^n \beta_j \ln X_{ij} + \varepsilon_i \quad (2)$$

Since ε_i consists two independent components u , the symmetric component that reflecting the technical inefficiency that having a value of zero for the farmers producing on the frontier or less than zero for the farmers producing below the frontier, and v , the random variability in output as of the uncontrollable factors like weather calamities and diseases outbreaks, the equation can be rewritten as:

$$\ln Y_i = \beta_0 + \sum_{j=1}^n \beta_j \ln X_{ij} + (v + u) \quad (3)$$

In estimating stochastic frontier, the two-step estimation has drawbacks and fail to satisfy the assumptions [17]. Therefore, the single step estimation was used in this specific work. In addition to estimation of farmer's inefficiency score, factors affecting farmer's technical inefficiency also assessed in this research.

The inefficiency score was estimated using the function dividing the realized output by the stochastic frontier output. The functional form can be written as:

$$TE_i = \frac{f(X_i, \beta_n) e^{V_i - U_i}}{f(X_i, \beta_n) e^{V_i}} = e^{-U_i} = e^{f(Z_i, \delta_i) + \omega_i} \quad (4)$$

Where: u_i = inefficiency score for i^{th} farmer,

Z_i = vector of explanatory variables explaining the farmers' inefficiency,

δ_i = vector of unknown parameters to be estimated, and

ω_i = unobservable random variables, distributed with 0 mean and unknown variance.

The value of the technical efficiency ranges from zero to one. If the value equals one, the actual production is equal with the frontier production, and the farmer is said to be efficient. Based on Battese and Coelli [18], the linear form of the inefficiency function can be rewritten as:

$$u_i = \delta_0 + \sum_{i=1}^n \delta_i Z_i + \omega_i \quad (5)$$

Economic Efficiency: Economic efficiency was estimated using the stochastic cost function. It was calculated using the ratio of the efficient cost (minimum cost) to the actual cost. The analytical framework for stochastic cost function used for estimating the economic efficiency was expressed as follows:

$$C_{ij} = f(X_i, Y_i, \beta_i) e^{\omega_i} \quad (6)$$

Where: C_{ij} = i^{th} farmer's observed cost of potato production,

X_i = a vector of inputs used by farmer i , producing Y_i output of potato,

ω_i = the composite error of μ_i (the inefficiency parameter), and δ_i (the stochastic term associated with random variations in production),

β_i = a vector of parameters associated with the production function.

Equation no. 6 can be rewritten by decomposing the error terms as:

$$C_{ij} = f(X_i, Y_i, \beta_i) e^{(\delta_i + \mu_i)} \quad (7)$$

Therefore, the economic efficiency can be calculated as follows:

$$EE = \frac{C_i}{C_i^*} \quad (8)$$

Where: C_i = farmer i^{th} observed cost for producing potato, C_i^* = the frontier cost of producing potato, that is assumed economically efficient cost.

Accordingly, equation 8 can be expressed as:

$$EE = \frac{f(X_i, Y_i, \beta_i) e^{(\delta_i + \mu_i)}}{f(X_i, Y_i, \beta_i) e^{(\delta_i)}} = e^{\mu_i} \quad (9)$$

From this equation, e^{μ_i} is the economic efficiency score that ranging from zero to one similar to that of technical efficiency. The score value of one is to mean the farmer is cost efficient.

Allocative efficiency: The allocative efficiency on the other hand was estimated using the technical efficiency and economic efficiency scores. This score measures the efficiency of input allocated for production of specific output, that is potato in this specific case. According to Farrel [19], the functional form of allocative efficiency can be expressed as:

$$AE_i = \frac{EE_i}{TE_i} \quad (10)$$

Where: AE_i , EE_i and TE_i are allocative, economic and technical efficiency of the i^{th} farmer in potato production.

Using equations 4, 9 and 10, the allocative efficiency can be rewritten as:

$$AE_i = \frac{e^{\mu_i}}{e^{-\mu_i}} \quad (11)$$

Where: e^{μ_i} and $e^{-\mu_i}$ are economic and technical inefficiency parameters.

3. Results and Discussion

3.1. Descriptive Results

3.1.1. Descriptive Results for the Production Variables

The mean potato yield is about 9810 kilograms per hectare, with minimum and maximum yields of 1400 and 33330 kilograms (see Table 1). According to the report of central statistical agency [7], the average potato per hectare for Ethiopia and Oromia was 13279 and 12047 kilograms respectively. Based on this, the average productivity of potato for the sample households was below the national and regional average. On average, about 15 man-equivalent labor were used

to manage one hectare of potato farm from land preparation to processing and packing. About, 259.44 kilograms of fertilizer was used per hectare, that ranged from 100 to 370.54 kilograms. The average potato seed used per hectare was 19473 kilograms, with minimum and maximum seed rate of 480 and 46667 kilograms respectively. In the study area, the average land allocated for potato production was 0.38 hectare, that ranged from 0.02 to 1.5 hectares. The result also showed that the average number of tillage study area was four times, and the mean oxen-day per hectare was 25. Each potato farmer in the study area applies about 1.4 kilograms of different agro-chemicals per one hectare of potato production plot.

Table 1. Descriptive results for production variables.

Variable	Mean	Std. Dev.	Min	Max
Yield (kg)	9810.01	6535.90	1400.00	33330.00
Labor (man)	15.52	7.45	2.00	36.00
Fertilizer (kg)	259.44	59.04	100	370.54
Seed (kg)	1947.30	846.11	480.00	4666.70
Plot size (ha)	0.38	0.29	0.02	1.50
Oxen (day)	25.89	10.28	6.00	55.80
Chemical (kg)	1.48	1.19	0.10	4.00

Source: Computed from own survey.

3.1.2. Descriptive Results for Socio-economic, Demographic, and Institutional Factors

From the result in Table 2, about 88% (88.04) of the sample households were male headed, and 12% were female headed households. The mean age of the sample households was 40.53 years, that ranging from 18 to 75. A household in the study area on average have a family member more than 4 (4.45), and the average livestock holding measured in tropical livestock unit is 7. The educational level ranged from 0 to 15, having a mean 5 years of schooling. The result also revealed that farm households in the study area have more than 10 years of experiences in potato production.

The mean distance from key institutions like the main market, cooperative unions, farmers' training center (FTC) and distance from the irrigation site were 5.4, 4.7, 4.4 and 2.2 kilometers respectively. Only 7.3% of the sample households used credit, while 92.7% did not used. 49% and 32% of the sample households have 1 and 2 dependent family members, while 32% did not have dependent family members. The average land ownership in the study area is 1.5 hectares, that ranged from 0 to 4.5 hectares. From the result, potato disease is the major problem and more than a half of the sample households (52%) reported occurrence of different potato diseases on their potato farm plot during the study season (see Table 2).

Table 2. Descriptive results for demographic, socio-economic and institutional factors.

Variable	Mean	Standard deviation	Minimum	Maximum
Sex of the head	0.88	0.33	0.00	1.00
Age of the head	40.53	12.04	18.00	75.00
Family size	4.45	2.11	1.00	11.00
Livestock holding	7.07	3.92	0.00	17.51
Education of the head	4.85	4.09	0.00	15.00
Experience in potato	10.07	8.28	1.00	45.00
Distance from market	5.44	3.76	0.01	18.00
Distance from cooperative	4.73	2.34	0.08	12.00
Distance from FTC.	4.48	2.22	0.01	12.00
Access to Credit services	0.07	0.26	0.00	1.00
Dependency ratio	0.87	0.70	0.00	2.00
Total Land own (ha)	1.52	1.23	0.00	4.50
Distance from irrigation site	2.23	0.77	1.00	4.00
Occurrences of crop diseases	0.51	0.50	0.00	1.00

Source: computed from own survey.

3.2. Econometric Results

3.2.1. Maximum Likelihood Estimation

To assess the technical, allocative and economic efficiencies

of potato farmers, the stochastic frontier model and Cobb-Douglas production functions were used. Before the estimation of the stochastic frontier, the variance inflation factor (VIF) test was done, and the mean VIF was 1.5. All the included

variables had a VIF value ranging from 1.03 to 3.1.

Table 3. Maximum likelihood estimation using different distributional approaches.

Variables	Half normal distribution		Exponential distribution		Truncated normal distribution	
	Coefficient	St.dev	Coefficient	St.dev	Coefficient	St.dev
Log of yield						
Log of seed	0.27***	0.05	0.28***	0.05	0.27***	0.05
Log of labor	0.69***	0.12	0.70***	0.12	0.70***	0.12
Log of oxen	0.29***	0.07	0.30***	0.07	0.30***	0.07
Log of fertilizer	0.18***	0.04	0.19***	0.04	0.18***	0.04
Log of plot size	0.20***	0.07	0.19***	0.07	0.19***	0.07
Log of chemical	0.13***	0.03	0.13***	0.03	0.13***	0.03
_cons	2.27***	0.71	2.01***	0.67	2.04***	0.68
/lnsig2v	-2.04	0.26	-1.88	0.17	-	-
/lnsig2u	-1.56	0.47	-2.91	0.52	-	-
sigma_v	0.36	0.05	0.39	0.03	0.15	0.03
sigma_u	0.46	0.11	0.23	0.06	1.97	6.02
sigma2	0.34	0.07	0.21	0.02	2.12	6.03
Lambda	1.27	0.15	0.60	0.09	13.11	-
/mu	-	-	-	-	-7.55	25.84
/lnsigma2	-	-	-	-	0.75	2.85
gamma	-	-	-	-	0.92	0.19
Log likelihood	-188.38	-	-188.11	-	-188.09	-
Wald chi ² (6)	338.63	-	381.86	-	373.53	-
Prob > chi ²	0.000	-	0.000	-	0.000	-

*** shows the significance levels at 1%

Source: Computed from own survey data.

The three distributional approaches of stochastic frontier model (half normal, exponential and truncated normal distributions) were used for maximum likelihood estimation. According to the result, all the production variables positively and significantly affected potato yield at 1%, which is in line with economic theory. The result also showed that the value of lambda is greater than one in both truncated and half-normal distributions, showing the existence of the inefficiency in potato production, the value of gamma is showing that 92% of the inefficiency of the farmers were explained by the variables used in the model, and the prob > chi² = 0.000 confirms that the null hypothesis (there is no inefficiency in potato production) was rejected. Moreover, (see Table 3).

According to Coelli [20], if there is an inefficiency in a production, the residual term will negatively skew, and derivation of one-sided test is recommended. Truncated normal distribution is the only method that allows the single-step estimation, combining both production and inefficiency variables simultaneously in a single step, and avoid the bias to be occurred when using a two-step estimation. Therefore, stochastic frontier model of the truncated normal distributional was chosen for this specific research, and the result was presented in Table 4. According to the result, all the production variables significantly affected potato yield, while only six out of fifteen variables (age, sex, experience, distance from cooperative unions, distance from farmers' training center and occurrence of crop disease) significantly affected technical efficiency of potato farmers. The coefficients for each variable were explained as follows:

Seed used per hectare: Amount of potato seed used per hectare positively and significantly affected potato yield per

hectare at 1% probability level. Households using more potato seed rate harvests more potato yield per hectare compared to households using less potato seed per hectare. From the result, 1% increase in potato seed per hectare is likely to increase yield by 0.3% (see Table 4). This result is in line with Mburu, Okello, Belete, Ahmed and Andaregie et al [21–25].

Man-equivalent labor: This variable had a significant effect on yield at 10%, indicating positive relation between labor used per hectare and yield harvested per hectare. From the result, increasing the labor by 1 percent is likely to increase the potato yield per hectare by 0.1 percent (see Table 4). This result is similar with Belete, Ahmed and Andaregie et al [23–25].

Oxen-day used: This variable is the number of a pair of oxen used for land preparation (tillage). According to the result in Table 4, this variable had positive and significant effect on potato yield at 1%, indicating the existence of positive relation between the number of the pair of oxen used for land preparation and the yield harvested. The coefficient showed that other things remaining constant, 1% increase in oxen-day used on per hectare of land is likely to increase the yield of potato per hectare by 0.2%. This result is similar with Okello, Belete and Wassihun et al [22, 23, 26].

Amount of fertilizer used: This variable is the amount of fertilizer used per hectare of potato plot, and this variable also positively and significantly affected potato yield at 5%. Households applying more amount of fertilizer per hectare of land harvested more yield compared to those households applying lesser fertilizer. The coefficient is indicating that increasing fertilizer applied by 1% is likely to increase the yield per hectare by 0.2% (see Table 4). This result is similar

with Mburu, Ahmed and Wassihun et al [21, 23–26].

Plot size: Plot size allotted for potato production had positive and significant effect on the yield at 1%. Households allocating larger proportion of their plot to potato production were more efficient than those allotting less land for potato. The coefficient is indicating that increasing land allotted to potato production by 1% is likely to increase potato yield per hectare by 0.1% (see Table 4). This result is similar with Okello, Belete, Ahmed and Andaregie et al [22–25].

Chemicals applied: This variable represents different agrochemicals sprayed on per hectare of potato plot. This variable also positively and significantly affected potato yield per hectare at 1%. From this result, sample households who applied more chemicals on a hectare of potato farm harvested more yield of potato per hectare. The coefficient indicates that increasing chemical application per hectare by 1% is likely to increase potato yield by 0.1% (see Table 4). This result is similar with Mburu, Ahmed and Khan et al [21, 23, 27].

Sex of the head: This variable negatively and significantly affected technical inefficiency at 10% significance. The negative coefficient indicates that male household heads are less inefficient compared to female headed households. In other words, male households are technically more efficient compared to female headed households. This is due to the fact that agricultural activities are mainly practiced by males in the study area, and females mainly do housework (see Table 4). This result is in line with Ahmed et al [23].

Age of the head: Age of the household head positively and significantly affected technical inefficiency at 5%. This means the variable has a negative effect on the technical efficiency of the farm households. From the result, aged households are technically less efficient compared to the

younger households. The coefficient is showing that one year increase in age of the head is likely to increase technical inefficiency by 0.007% (see Table 4). This result is similar with Wassihun et al [26].

Experience in potato farming: This variable on the other hand, negatively and significantly affected the technical inefficiency variable at 5%. In other words, the variable has a positive effect on farmers' technical efficiency. According to this result, more experienced household heads are technically more efficient than less experienced household heads. From the coefficient, one year increase in experience in potato farming is likely to increase farmers' technical efficiency, or reduce farmers' technical inefficiency by 0.01% (see Table 4). This is in line with Andaregie and Khan et al [25, 27].

Distance from cooperative and FTC: Both variables negatively and significantly related to households' technical efficiency at 10%. Households living away from institutions were technically inefficient compared to those living nearer to the institutions. From the coefficient, 1% increase in distance from farmers' training center is likely to increase farmers' inefficiency in potato production by 0.019%. Similarly, 1% increase in distance from cooperative unions is likely to increase farmers' inefficiency in potato production by 0.054%.

Occurrence of different potato diseases: This variable is also positively and significantly related with households' technical inefficiency in potato production. In other words, occurrence of potato disease negatively related to households' technical efficiency, and the result is showing that households whose potato farms affected by disease were less efficient compared to households whose farm were not diseased (see Table 4).

Table 4. The result of truncated normal distribution of stochastic frontier model.

Number of obs. = 301 Log likelihood = -148.2167			Waldchi2(6) = 252.35 Prob > chi2 = 0.0000			
Log of yield	Coef.	Std. Err.	z	P>z	[95% Conf. Interval	
Frontier						
Log of seed used	0.226	0.060	3.790	0.000***	0.109	0.343
Log of labor used	0.223	0.049	4.570	0.000***	0.128	0.319
Log of oxen day	0.218	0.067	3.260	0.001***	0.087	0.349
Log of fertilizer	0.415	0.108	3.840	0.000***	0.203	0.627
Log of plot size	0.143	0.035	4.090	0.000***	0.074	0.212
Log of chemical	0.144	0.029	5.010	0.000***	0.088	0.200
_constant	4.431	0.708	6.250	0.000***	3.042	5.819
Mu						
Sex of the head	-0.180	0.100	-1.810	0.071*	-0.376	0.015
Age of the head	0.008	0.004	2.180	0.029**	0.001	0.015
Family size	-0.012	0.019	-0.630	0.527	-0.049	0.025
Livestock holding	-0.003	0.010	-0.340	0.734	-0.022	0.016
Education of the head	-0.013	0.010	-1.330	0.185	-0.031	0.006
Experience in potato	-0.012	0.005	-2.410	0.016**	-0.023	-0.002
Distance from market	0.019	0.012	1.560	0.119	-0.005	0.042
Distance f/cooperatives	0.054	0.028	1.950	0.051*	0.000	0.109
Distance from FTC	0.053	0.027	1.940	0.052*	-0.001	0.107
Access to credit	0.074	0.138	0.540	0.591	-0.196	0.344
Extension contacts	-0.100	0.105	-0.960	0.339	-0.305	0.105
Dependency ratio	0.043	0.052	0.820	0.414	-0.060	0.145
Size of land owned	-0.026	0.031	-0.820	0.413	-0.087	0.036
Distance from irrigation	0.009	0.047	0.200	0.843	-0.084	0.102
Crop disease	0.141	0.076	1.870	0.061*	-0.007	0.289
constant	-0.086	0.340	-0.250	0.800	-0.753	0.580

Number of obs. = 301 Log likelihood = -148.2167			Waldchi2(6) = 252.35 Prob > chi2 = 0.0000		
Log of yield	Coef.	Std. Err.	z	P>z	[95% Conf. Interval
U-Sigma	-2.033	0.348	-5.850	0.000***	-2.714 -1.351
V-Sigma	-2.590	0.369	-7.030	0.000***	-3.313 -1.868
Sigma_u	0.362	0.063	5.750	0.000***	0.257 0.509
Sigma_v	0.274	0.050	5.430	0.000***	0.191 0.393
Lambda (λ)	1.322	0.106	12.440	0.000***	1.114 1.530

*, ** and *** shows the level of significance at 10%, 5% and 1%

Source: Computed from own survey.

3.2.2. Estimation of Efficiency Scores

Technical, allocative and economic efficiency scores were estimated, and the result was presented in Table 5. According to the result, not all potato farmers were efficient since their efficiency scores were below 100 percent. The mean technical, allocative and economic efficiency for the sample

households were 61.21, 79.56 and 50.23 percent respectively. From the result, households can increase their potato production by 38.78%, and they can also reduce their cost of potato production by 49.76%. This result is similar with Okello and Ahmed and Melesse [22, 28].

Table 5. Technical, allocative and economic efficiency scores.

Variable	Obs.	Mean	Std. Dev	Minimum	Maximum
Technical efficiency (TE)	301	0.6121587	0.1758259	0.2099201	0.9135593
Allocative efficiency (AE)	301	0.7956858	0.0875088	0.5767937	0.9524871
Economic efficiency (EE)	301	0.5023394	0.1885496	0.1210806	0.8701535

Source: Computed from own survey data.

4. Conclusion and Policy Recommendations

This research was designed to assess the technical, allocative and economic efficiency of small-scale potato producers in central Oromia, Ethiopia, and the result revealed the existence of higher inefficiency in potato production in the study area. From the result, farmers could reallocate their resources to achieve maximum possible potato yield using minimum possible cost. They could increase their potato produce by 38.78%, and reduce their cost of production by 49.76%. Not only the inefficiency rate assessed, but also factors affecting farmers' inefficiency were assessed.

In order to improve farmers' efficiency and attain maximum production that ensuring framers' food security and alleviate poverty, agricultural policy interventions that improving technical, allocative and economic efficiency like utilization of optimum different agrochemicals on potato fields, and availing the institutions serving as technical and material sources for farmers are paramount important as farmers living nearer to farmers' training centers and cooperative unions were more efficient compared to those farmers living away from these institutions.

In the study area, potato diseases were the major problem, and households whose potato production field affected by different diseases were less efficient. Moreover, households using different agrochemicals on their potato production plots were more efficient than those not using chemicals. Therefore, establishment of active and functional institution plays important role in improving household efficiency.

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