American Journal of Agriculture and Forestry
2024, Vol. 12, No. 5, pp. 325-339
https://doi.org/10.11648/j.ajaf.20241205.12

Research Article

Economic Efficiency of Potato Production by Smallholder Farmers in West Arsi Zone, Oromia Region Ethiopia

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Abstract

This study investigated Economic Efficiency of Potato Production in West Arsi Zone, Oromia Region, Ethiopia. Structured questionnaires were used to collect data from 117 respondents randomly selected from designated locations in West Arsi Zone. A stochastic production frontier function was fitted to the sample households. The result revealed that the mean TE, AE and EE was about 75.60%, 91.41% and 69.07% of for potato production. The sum of the partial elasticity of all inputs were 1.17 for Potato indicating an increase in all inputs at the sample mean by one percent increase by 1.17%. This indicates that the production function is characterized by increasing returns to scale productions. The result of Tobit model estimation indicated that the technical efficiency of Potato production in West Arsi Zone is significantly influenced by the variables potato farming experience, education level, social participation and Extension contact affect efficiency positively while, distance to FTC affect technical efficiency negatively. The mean potato yield difference between sample farmer due to technical efficiency variation was 31.04 qt per ha. District office of Agriculture, stockholders and concerned bodies should focus on farmers experience sharing, providing technical support and farmers practice different social participation to improve his/her income could jointly contribute to the improvement in efficiency of Potato farmers in West Arsi Zone.

Keywords

Efficiency, West Arsi, Frontier Model, Tobit Model

1. Introduction

1.1. Background of the Study

Vegetable growing is one of the priority sectors in agriculture. Vegetables occupy an important place in the food by being an important component of the human diet through source of micronutrients for human nutrition, a source of livelihood to people along the value chain including farmers, traders, processors and transporters, it contributes in food security, employment, foreign exchange and it has been key in alleviation of poverty especially in rural areas where production is intensive [1]. According to [2] to improve income and provide gainful employment, diversification from grain crops to high value crops like vegetables have appeared to be an essential strategy for agricultural growth for any developing country.

Vegetables are integral part of the farming system in Ethiopia. They are grown as sole or intercropped, rainfed or irrigated and plays crucial role in the economy of the country. Its demand is also growing, implying the need for concerted effort to improve productivity through sustainable supply of

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Received: 17 June 2023; **Accepted:** 7 December 2023; **Published:** 11 September 2024

high yielding vegetable varieties [3].

In Ethiopia, most of the soil types in fruits and vegetables producing regions of the country range from light clay to loam and are well suited for horticultural production. Vegetable production is becoming an increasingly important activity in the agricultural sector of the country mainly due to increased emphasis of the government on the commercialization of smallholder farmers [4]. Integrating vegetable production into a farming system has contributes substantially to the Ethiopia's economy in terms of food and nutrition security as the vegetables complement stable foods for a balanced diet by providing vitamins and minerals [5]. An economically efficient input-output combination would be on both the frontier function and the expansion path. On the other hand, economic efficiency refers to the appropriate alternative of inputs and outputs combination according to their price relation or the ability of the firm to maximize profit by equating marginal revenue product of inputs to their respective marginal costs [6]. Evidence of low productivity in vegetable production was observed because of inefficiency in resource use [2]. Farm efficiency no doubt is an important subject in developing countries agriculture [7]. [8] Provided the impetus for developing the literature on empirical estimation of technical, allocative and economic efficiency. Among the approaches used in measuring efficiency stochastic frontier approach has been used extensively in measuring the level of inefficiency/efficiency.

1.2. Statement of the Problem

Vegetables are commonly practiced by the rural private peasant holders even in remote areas. Vegetables took up about 1.68% of the area under all crops at national level [9]. Irish potato is the first root crops produced in Ethiopia next to Taro/*Godere* and sweet potato that accounts 70,132 ha in 2016 *meher* cropping season. The estimated producers of potatoes in both *belg* and *meher* season was accounted 3,705,879 holders in the country. Productivity of potato is 13.678 ton/ha [10]. Oromia is the major potato producing region that constitutes 51% of the national potato production. According [11] West Arsi is a major potato producing zone in Oromia National Regional state that smallholder farming has diversified from staple food subsistence production into more market oriented and high value commodities. West Arsi zone potato yield was very low (10 ton/ha) even though the zone are suitable for quality potato production [12].

The fruit and vegetable sector compares favorably with cereals and other food crop sectors in terms of employment and income generation. The production of vegetables has a comparative advantage particularly under conditions where arable land is scarce and labor is abundant. The traditional small scale fruit and vegetable production and marketing sector is an important sector in terms of employment, income and scale of production [13]. Potato (*Solanum tuberosum L.*) is the world's third most important food crop in overall production after rice and wheat, and is a food security crop in some countries, including Ethiopia [14].

Despite the increasing importance of vegetables, the production in Ethiopia, does not meet the need of the country's population for vegetable products and/or the production levels of vegetables are still far below their potential. This was because of, there was inadequate knowledge on improved production systems, marketing, small scale farming systems and poor pre and post-harvest handling techniques and in general, there were inefficiency in production of vegetables [15].

There is, however, little knowledge about the level of efficiency of potato farmers who have been producing, and the underlying factors affecting them in West Arsi Zone. Also the knowledge on the source of inefficiency for these commodities is scanty. Therefore, a thorough study on these issues may help to identify the production constraints at farm level and thereby develop policy recommendations to increase potato production and productivity so that it will contribute to food security and poverty reduction efforts. Therefore, a thorough study on these issues may help to identify the production inefficiency constraints at farm level and thereby develop policy recommendations to increase potato production and productivity so that it will contribute to food security and poverty reduction efforts. There are no previous studies conducted in the area of potato efficiency dealing exclusively with technical efficiency of farmers and the factors considered to be important in determining their efficiency farming in west Arsi Zone. Therefore, the analysis of technical efficiency of potato farming is very important to improve potato production.

1.3. Objectives of the Study

1. To estimate technical, allocative and economic efficiencies among potato producing smallholder farmers
2. To identify the factors affecting allocative and economic efficiency of potato producing smallholder farmers.

2. Research Methodology

2.1. Description of the Study Area

This study was conducted in Kofale and Shashamane districts of West Arsi zone, Oromia region. It covers an area of 11,776.72 km^2, divided into 12 districts (weredas). Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), this Zone has a total population of 1,964,038, of whom 973,743 are men and 990,295 women. 272,084 or 13.85% of population are urban inhabitants [16].

Shashamane district is one of the districts in West Arsi Zone. It shared bordered in South Sidama region, on the East by Kofale district, on the North by Negelle Arsi and on the West Shala district. It has 37 rural kebeles and the annual temperature ranges from 12℃ to 27℃, annual rain fall ranges from 800mm to 1100mm with attitude ranges 1600 to 2800 m. a. s. l. Type of crop produced in the district was Teff, wheat, maize, millet, haricot bean, potato, head cabbage, normal cabbage and carrot. The district has 32040 ha of ultivated land 8040ha forest land,2300 ha grazing land,300 land for construction and 23820ha others such as swampy, mountainous or otherwise unusable [17].

Kofele is one of the Districts in the Oromia Region of Ethiopia. It is named after the administrative center of the District, Kofele. Part of the West Arsi Zone, Kofele is bordered on the south by the Kokosa, on the west by the Southern Nations, Nationalities and Peoples' Region, on the northwest by the Shashamene (District), on the north by Kore, on the east by Gedeb Asasa, and on the south east by Dodola. Other towns in Kofele include Wabe Gefersa. The altitude of this woreda ranges from 2000 to 3050 meters above sea level; Mount Duro is the highest point. Rivers include the 35 kilometers of the Anjelo, 30 kilometers of the Totalamo, and 35 kilometers of the Ashoka, all of which are tributaries of the Shebelle River. A survey of the land in this District shows that 30% is arable or cultivable, 29% pasture, 2.9% forest, and the remaining 38.1% is considered swampy, mountainous or otherwise unusable. Vegetables are an important cash crop; hides and skins are the primary export for Kofele [18].

2.2. Data Types, Sources and Methods of Data Collection

Both primary and secondary data source was used for this study. The primary data was collected using semi-structured questionnaire, key informant interviews, and focus-group discussions. Prior to the actual data collection, semi- structured questionnaire was pre-tested to ensure clarity, validity, and sequence of the question. The questionnaire was pre-tested in each selected Shashamane and Kofale Districts and revised according to the feedback obtained. The major sources of secondary data were from both published materials and online resources such as Central Statistics Agency (CSA), West Arsi zone agriculture office, Shashamane District of Agricultural Office and Kofale District Agricultural Office.

2.3. Sampling Procedure and Sample Size

The study was based on the data that was obtained through a farm household survey administered to sample farm households drawn through multi-stage sampling techniques. The three-stages that involve the selection of (1) Sample *districts*, (2) *Peasant Association (PA)* and (3) Smallholder farmers are as follows:

Stage 1: In the first stage two *districts* was purposively selected based on potential of potato volume of production from West Arsi zone with the collaboration of West Arsi zone agricultural office expert.

Stage 2: In the second stage, three potato growing *PA was selected* from each of the two selected *districts* using simple random sampling method and proportional size.

Stage 3: In the third stage, 117 Potato producer households were randomly selected, household sample size was determined based on [18] formula:

$$n = \frac{N}{1+N(e)2}$$

Where: n = is the sample of potato producer households that in West Arsi Zone, N = is the total number of potato producer households in the Zone and e = 0.092 is the level of precision. The total number of households is 16,650 so sample size is calculated as follows:

$$n = \frac{16,650}{1+16,650\ (0.092)2} = 117.$$

2.4. Method of Data Analysis

In this study, descriptive and inferential statistics and econometric models were used to analyze data.

2.4.1. Descriptive Analysis

Descriptive statistical tools such as average, ratios, percentages, frequencies, etc. were applied to describe household and farm characteristics of the study areas while inferential statistical methods such as χ^2 and t test were used to compare households in the two *district* in terms of household and farm characteristics.

2.4.2. Econometrics Model

The analytical models for estimating production function, dual cost function and efficiency decomposition techniques of potato producing smallholder farmers. Stochastic Frontier approach (SFA) was used for its ability to distinguish inefficiency from deviations that are caused by factors beyond the control of farmers. Farmers possess the potential to achieve both technical efficiency in farm enterprises, but inefficiency may arise due to a variety of factors, some of which are beyond the control of the farmers. The assumption that all deviations from the frontier are associated with inefficiency, as assumed in DEA, is difficult to accept, given the inherent variability of agricultural production due to many factors like climatic hazards, plant pathology and insect [20]. The stochastic frontier model can be expressed in the following form.

$$Yi = F(Xi;\ \beta)\exp(Vi - Ui) \quad i=1,\ 2,\ 3,\ldots\ n \qquad (1)$$

Where Yi is the production of the i^{th} farmer, Xi is a vector of inputs used by the ith farmer, β is a vector of unknown parameters, Vi is a random variable which is assumed to be $N\sim\ (0, \delta 2)$ and independent of the Ui which is nonnegative random variable assumed to account for technical inefficiency in production. The variance parameters for Maximum Likelihood Estimates are expressed in terms of the parameterization

$$\delta s^2 = \delta v^2 + \delta^2 \text{ and}$$

$$\gamma = \frac{\delta^2}{\delta s^2} = \frac{\delta^2}{\delta v^2 + \delta^2} \quad (2)$$

Where,

σ^2 is the variance parameter that denotes deviation from the frontier due to inefficiency

$\sigma^2 v$ is the variance parameter that denotes deviation from the frontier due to noise

σs^2 is the variance parameter that denotes the total deviation from the frontier

Cobb–Douglas stochastic production frontier function was used to estimate the production function and the determinants of technical efficiency of potato producers in the selected districts of West Arsi zone. According to [21], inadequate farm level price data together with little or no input price variation across farms in Ethiopia precludes any econometric estimation of a cost function. [22] indicated that the corresponding dual cost frontier of the Cobb Douglas production function could be rewritten as:

$$Ci = C(Wi, Yi *;\ \alpha) \quad (3)$$

Where i refers to the i^{th} sample household; Ci is the minimum cost of production; Wi denotes input prices; Yi* refers to farm output which is adjusted for noise vi and α’s are parameters to be estimated. To estimate the minimum cost frontier analytically from the production function, the solution for the minimization problem given in Equation 4 is essential [21].

$$\text{MinCx} = \sum \omega_n X_n$$

$$\text{Subject to } Y^{i}_{k}{}^{*} = \hat{A}\prod_{nXn}{}^{\beta}_{n} \quad (4)$$

Where;

$\hat{A} = \exp(\beta_o)$

ω_n =input price

β_n = parameter estimates of the stochastic production function

Y_{ki}*= input oriented adjusted output level from Equation 1.

The economically efficient input vector for the i^{th} firmer derived by applying Shepard’s Lemma and substituting the firms input price and adjusted output level into the resulting system of input demand equations.

$$\frac{\alpha Ci}{\alpha \omega n} = Xi(\omega i, Yi *; \theta) \quad (5)$$

Where θ is the vector of parameters and n=1,2,3,... N inputs

The observed, technically and economically efficient cost of production of the ith farm are equal to, ωiXi and $\omega i'Xi^t$. Those cost measures are used to compute technically and economically efficient indices of the ith farmer as follows:

$$TE_i = \frac{\omega i\prime Xit}{\omega i\prime Xi} \quad (6)$$

$$EE_i = \frac{\omega i\prime Xit}{\omega i\prime Xi} \quad (7)$$

allocative efficiency index of the i^{th} farmer can be derived from Equations 7 and 8 as follows;

$$AEi = EEi/TEi = \frac{\omega i\prime Xit}{\omega i\prime Xit} \quad (8)$$

2.4.3. Determinants of Efficiency Scores

Factors affecting technical efficiency of potato producers were computed by two-limit Tobit model. The model is adopted because the efficiency scores are double truncated at 0 and 1 as the scores lie within the range of 0 to 1 [23]. The following relationship expresses the stochastic model underlying Tobit [24]:

$$\text{Yi} = \beta o + \sum \beta_m Z_{jm} + \text{Ui} \quad (9)$$

Where yi* = latent variable representing the efficiency scores of farm j, β = a vector of unknown parameters, Z_{jm} = a vector of explanatory variables m (m = 1, 2,..., k) for farm j and μ_j= an error term that is independently and normally distributed with mean zero and variance σ^2.

$$Yi = \begin{cases} 1 \text{ if yi} * \geq 1 \\ \text{yi} * \text{ if } 0 < yi * < 1 \\ 0 \text{ if yi} * < 0 \end{cases} \quad (10)$$

2.4.4. Description of the Variables Used in Parametric Stochastic Production and Cost Frontier Analysis

Table 1. *Description of the variables used in parametric stochastic production and cost frontier analysis.*

Variables	Variable description and measurement	Unit	Expected signs
Ln (output)	*Natural log of the quantity of Potato Cultivated*	*Kilogram*	

Variables	Variable description and measurement	Unit	Expected signs
Ln (labor)	Natural log of family, exchange and hired labor used in production	Man days	+/-
Ln (land)	Natural log of farm land under potato cultivation	Hectares	+/-
Ln (fertilizer)	Natural log of the quantity of fertilizer used in production	Kilogram	+/-
Ln(others)	Natural log of the quantity of seed, pesticides and herbicides used in production	Kilogram and liters	+/-
Ln (Ci)	*Log of the cost of potato production for the ith farmers*	*Birr*	
Ln (Clabour)	Natural log of the total price of labor during farming (Size of laborers * hrs/day * Number of days* price/ day)	Birr	+/-
Ln (Cland)	Natural log of total rental price of land per hectare (Size of land * Price/hectare)	Birr	+/-
Ln(CFertilizer)	Natural log of the total price of fertilizer per hectare (Kilogram * Price/kg)	Birr	+/-
Ln (Cothers)	Natural log of the total price of seed(Kilograms * price/kg) and Natural log of total price of pesticides and herbicides (Liter * price/liter)	Birr	+/-

2.4.5. Description of the Variables Hypothesized to Influence Efficiencies of Potato Production

Table 2. *Description of the variables hypothesized to influence efficiencies of potato production.*

Dependent variables			
TE (Technical Efficiency), AE (Allocative Efficiency) and EE (Economic Efficiency)			
Independent variables	**Variable description and measurement**	**Unit**	**Expected signs**
Demographic characteristics			
Sex	Sex of household head (1= female, 0=male)	Dummy	-
Age	Age of household head	Years	+
Household size	Number of persons per household	Number	+
Socioeconomic characteristics			
Education	Number of years of formal education (0 if illitrate)	Years	+
Livestock	Total number of livestock owned	TLU	+
Farm attributes			
Experience in potato farming	Experience of farmer in potato production	Years	+
Farm size	Total farm size of the household	Hectare	+/-
Institutional services			
Extension contact	Frequency of extension contact during cropping period	Number	+
Distance of FTC	Distance of farmer house from FTC	Walking Hour	-
Cooperative	Membership of cooperative (1= yes, 0= no)	Dummy	+
Credit	Use of cash credit for potato (1= yes, 0 = no)	Dummy	+
Market access			
Market distance	Distance of farmer house from nearby market	Walking Hour	-

3. Results and Discusson

This chapter presents the findings of the study and discusses in comparison with the results of earlier similar studies. It is organized under three sections. The first section presents results of descriptive characteristics of sample respondents the study area. The second section is about estimation of technical, allocative and economic efficiencies of potato producing smallholder farmers. The third section is about factors affecting the level of technical and economic efficiencies of potato producing farmers.

3.1. Descriptive Statistical Results

In this sub-section, descriptive statistical results of variables such as age, family size, dependency ratio and experience presented and discussed. The average age of the sample respondents were found to be 39 years. This result implied that the sample respondents were work age group and can increase production if they get technology and training. The dependency ratio was about 1.39. The average family size of the sample households was 9.05 persons per household, which is more than the national average of 4.6 persons per household [25]. The farming experience of potato production was about 11.96 years. This implies that the producers can increase the efficiency as their experience increase since they were adult.

3.2. Socio-Economic Factors

3.2.1. Physical Factors

This sub-section presents socio-economic factors of sample respondents with regards to the farm income, cultivated land size, livestock holdings and participation in non/off-farm activities.

Cultivated land: Cultivated farmland land is land used by sample farm households to undertake agricultural production. The own average cultivated land holding size of the sample households was 1.47 hectares. The average areas covered by Potato during the year 2019 cropping season were 0.42 ha (Table 4).

Table 3. *Age, family size, Dependency ratio and farming experience of sample household heads.*

Commodity	Statistics	Age	Variables		
			Family size	Dependency ratio	Farming Experience
Potato (n=117)	Mean	39.50	9.05	1.39	11.96
	St. dev.	10.95	3.83	0.80	4.79

Source: Survey result, 2021

Table 4. *Land use and allocation system of HH.*

Commodity	Statistics	Land allocation and use in ha	
		Cultivated land	Area under Potato production
Potato (n=117)	Mean	1.47	0.42
	St. dev.	1.04	0.20

Source: Survey result, 2021

Livestock holdings: Livestock is one of the major assets for the farmers and also indicates their level of wealth in the study area. Types of livestock owned by households are oxen, cows, heifers, calves, horses, donkey, sheep, goat and poultry. Livestock provides traction power, manure, and is a source of cash that can be used to purchase goods for household consumption and production inputs. The average livestock holdings measured in terms of tropical livestock unit (TLU) were found to be 6.03. This is relatively a large number in the crop-livestock mixed farming system (Table 5).

Table 5. Livestock owned of households.

Commodity	Statistics	Variables
		TLU
Potato (n=117)	Mean	6.03
	St. dev.	4.12

Source: Survey result, 2021

Participation in non/off-farm activities: Off/non-farm activities refers to both self-employment in non-farm sectors such as petty trade, craft work/carpentry, blacksmith, and off-farm employment such as cash/food for work (safety net), daily labor, and guard. Out of the total households interviewed only 3.42% participated in non/off-farm activities. The result implies that participation of non/off-farm activity is low (Table 6).

Table 6. Participation in non/off-farm activities of sample households.

Commodity	Percent	Participation in non/off-farm		
		No	Yes	Total
Potato	No.	113	4	117
	%	96.58	3.42	100

Source: Own survey result, 2021

3.2.2. Human Capital Factors

This sub-section presents human capital factors of sample respondents with regards to the education and farming experience.

Educational status: Out of the total sample household heads, about 87.18% were literate and 12.82% illiterate. This shows that farmers can easily understand agricultural instructions and advice provided by the extension workers (Table 7). The average education level of literate sample household heads during survey period was about 6.4 years with the minimum of zero years (illiterate) and maximum of 12 years.

Table 7. Educational status of sample households.

Commodity	Statistics	Education status		
		Illiterate (0)	Literate (>0)	Total
Potato	No.	15	102	117
	%	12.82	87.18	100

Source: Survey result, 2021

3.2.3. Institutional Factors

Tis sub-section presents institutional factors of sample respondents with regard to variables including access to credit, access to extension service, participation in social organization and access to market information.

Participation in social organizations: Participation in social organization is believed to enhance information exchange and experience sharing among farm households on production. As shown in Table 8 about 79.49 % of the sample farmers participated in social organizations (Table 8).

Table 8. *Participation in social organization of HH.*

Commodity	Percent	Participation in social organization		
		No	**Yes**	**Total**
Potato (n=117)	No.	24	93	117
	%	20.51	79.49	100

Source: Survey result, 2021

Access to credit and market information:

Households with better information access are more likely to participate in crop production efficient way. In this study, ownership of communication equipment such as telephone, radio and television are used as a proxy to access to information. From total sample respondents interviewed, 65.81 % of sample respondents had access to market information (Table 9). Distance to Farmer training center (FTC):

Table 9. *Access to credit and market information of HH.*

Commodity	Percent	Access to credit service		
		No	**Yes**	**Total**
Potato (N=117)	No.	102	15	117
	%	87.18	12.82	100
Commodity	Percent	Access to market information		
		No	Yes	Total
Potato (n=117)	No.	40	77	117
	%	34.19	65.81	100

Distance to development center is used as proxy for assessing the accessibility of extension services to farmer in onion and tomato farming. Proximity to development center has advantage of obtaining technical supports form extension workers related to the utilization of technologies in tomato production. The average distances to travel from farm to the market center by sample farmers in the study area was 2.35 km (Table 10).

Distance to market center: Distance to market center included to capture the role of travel costs in influencing efficiency of production. The average distances to travel from farm to the market center by sample farmers in the study area was 10.75 km (Table 10).

Distance to all weather roads: Distance to all weather road also included to capture the role of travel costs in influencing cost. It is expected that longer distance to increase travel time and travel costs, which will have negative influence on economic efficiency. The average distance all-weather road from the study area was 1.48 km. The sample households in study area are sale their product at farm gate, as a result there is a problem of road directly connects from farm site to all-weather road (Table 10).

Table 10. *Distance all-weather roads and market of sample households.*

Commodity	Statistics	Variables		
		Distance to FTC	**Distance to Market center**	**Distance farm from all-weather road**
Potato (n=117)	Mean	2.35	10.75	1.48
	St. dev.	2.01	7.52	1.45

3.3. Results of the Econometric Model

Hypotheses stated in the model specification part and validity of the model which is used for analysis has to be tested before estimating the parameters of the model.

The appropriateness of the stochastic frontier model over the convectional production function can be tested using the statistical significance of the Stochastic Production Frontier Ordinary Least Square parameter gamma, Ý. The estimated value of gamma is equal to 99.86 for production Potato which is statistically significant at 1% level of significance. The estimated value of gamma signifies that 99.86 % of the variation in output is due to the variation in technical inefficiency among the farmers. This indicates that there is wider room to increase productivity of farmers in the study area through identification of principal factors affecting technical efficiency. Hence, the production function estimation using SPF analysis is more appropriate than convectional production function.

The other hypothesis testing is the test for returns to scale. The results of the estimation made under model specifications, constant and variable return to scale, show that the value of log-likelihood functions equal to -88.24 and -85.60 for Potato production. Thus, the log likelihood ratio test is calculated to be 5.28 and when this value is compared to the critical value of χ^2 at 4 degrees of freedom with 1% level of significance equals to 12.483. Therefore, the null hypothesis of no technical inefficiency was accepted. The sum of the partial elasticity of all inputs equals to 1.17 for Potato. This means an increase in all inputs at the sample mean by one percent will increase Potato by 1.17% in the study area. This reveals that the production function is characterized by increasing returns to scale for Potato production. This shows that the elasticity of mean value of output is estimated to be an increasing function of inputs for Potato production. The gamma (γ) of the MLEs of stochastic frontier production is 0.9986. This value is statistically significant implying that 99.86% of variability output from potato production is attributed to the technical efficiency of Potato production technic where as 0.14% due to random shocks in production.

The results of the estimated parameters revealed that all the coefficients of the physical variables conform to a priori expectation of a positive signs. The positive coefficient of land, labor, seed, Fertilizer and agro chemical implies that as each of these variables is increased, ceteris paribus, Potato output increased. The coefficients of the variables; land, seed, and fertilizer are significant even at 1% level of significance. Therefore, these are factors explaining Potato production in study the area [26].

The appropriateness of the stochastic frontier model over the convectional production function can be tested using the statistical significance of the Stochastic Production Frontier Ordinary Least Square parameter gamma, Ý. The estimated value of gamma is equal to 0.9976 for Potato cost of production. The estimated value of gamma signifies that 99.76% of the variation in output is due to the variation in allocative inefficiency among the farmers and remaining 0.24% of output variation is due to due to variation output. Hence, the production function estimation using SPF analysis is more appropriate than convectional production function (Table 11).

Table 11. *Estimated Potato stochastic production and cost frontier function.*

	Production frontier			**Cost frontier**	
Variables	**ML estimate**		**Variables**	**ML estimate**	
	Coefficient	**Std. Err**		**Coefficient**	**Std. Err**
Intercept	1.836 ***	0.6093114	Intercept	2.380***	0.2882335
LnLand	0.601 ***	0.1158212	*LnLandcost*	0.290***	0.0268099
LnLabor	0.104	0.0723129	*LnLaborcost*	0.163***	0.0257309
LnSeed	0.196 ***	0.0662501	*LnSeedcost*	0.248 ***	0.0231876
LnFertilizer	0.230 ***	0.065234	*LnFertilizercost*	0.163***	0.0249031
LnChemical	0.037	0.0865632	*LnChemicalcost*	0.063***	0.0217149
	∑β= 1.167				
ϭ2=ϭ 2u + ϭ 2v	124.612			12.014	
λ= ϭu / ϭ v	27.062	22.708		20.420***	8.239
γ (gamma)	0.9986 ***			0.9976	
Log likelihood	-85.6014			25.5278	

Variables	Production frontier		Variables	Cost frontier	
	ML estimate			ML estimate	
	Coefficient	Std. Err		Coefficient	Std. Err
LR test	5.29			9.35	

***, Significant at 1% significance level, Source: Own computation, 2021

3.4. Estimation of Technical, Allocative and Economic Efficiencies of Potato Producing Smallholder Farmers

The study indicated that 75.60% were the mean levels of Technical Efficiency of Potato. This in turn implies that farmers can increase their Potato production on average by 24.4% at the existing level of inputs and current technology by operating at full technical efficient level. There is huge gap among farmers in sample study which range 15.16% to 91.11% for Potato production. This result needs to extension intervention by arrange experience sharing between farmers to reduce the efficiency gap. On the other hand The Allocative efficiency and Economic efficiency of potato were about 91.40% and 69.07% respectively. This result indicates that there was a room to improve economic efficiency. (Table 12)

Table 12. Efficiency estimation by stochastic production frontier model.

Types of commodity	Efficiency	Mean	St. dev.	Minimum	Maximum
Potato	Technical Efficiency	0.756	0.116	0.152	0.911
	Allocative Efficiency	0.914	0.054	0.394	0.976
	Economic Efficiency	0.691	0.114	0.135	0.846

Source: Survey data, 2021

Table 13. Elasticities and returns to scale of the parameters of stochastic frontier

Variables	Potato
	Elasticities
LnLand	0.601
LnLabor	0.104
LnSeed	0.196
LnFertilizer	0.230
LnChemical	0.037
Returns to scale	1.167

Source: Survey data, 2021

3.5. Returns to Scale for Potato Production

The return to scale (RTS) analysis, which serves as a measure of total resource productivity, is given table 13. The maximum likelihood estimates (MLE) of the Cobb-Douglas based stochastic production function parameter of 1.167 is obtained from the summation of the coefficients of the estimated inputs (elasticities) of Potato. It indicates that Potato production in study area is stage I of increasing returns to scale where resources and production were believed to be efficient. This means an increase in all inputs at the sample mean by one percent will increase Potato by 1.167 % in the study area (Table 13).

3.6. Efficiency Among Potato Producers by Sample Districts

For both Shashemene and Kofale districts the Technical, Allocative and Economic efficiency was tested. The result showed that, Potato technical efficiency and economic efficiency significance difference among potato producers sample districts. The mean technical efficiency and economic efficiency were about 78.5% and 72.2% for Shashemene district and about 73.3% and 66.66% for Kofale district respectively.

Table 14*.* *Technical, Allocative and Economic efficiency among Potato producers by districts.*

Commodity	Efficiency	Mean	Districts		
			Shashamane	Kofale	t-Value
Potato	TE	Mean	0.785	0.733	2.477***
		Std. Dev.	0.077	0.135	
	AE	Mean	0.919	0.910	0.898
		Std. Dev.	0.026	0.069	
	EE	Mean	0.722	0.666	2.697***
		Std. Dev.	0.072	0.134	

*** Significant at 5% level. Source: Own survey result, 20213.7.

3.7. Determinants of Technical and Economic Efficiencies in Potato Production

Variance inflation factors (VIF) was computed for all explanatory variables that are used in the Tobit model and the result shows VIF values of less than 10 indicating multicollinearity was not a problem. Robust method was also employed to correct the possible problem of heteroscedasticity. Outliers were checked using the box plot graph so that there were no serious problems of outliers and no data get lost due to outliers.

The model chi-square test indicates that the overall goodness-of-fit of the Tobit model was statistically significant at 1% probability level which in turn indicates the usefulness of the model to explain the relationship between the dependent and at least one independent variable. The result of Tobit model estimation indicated that the technical efficiency of Potato production in West Arsi Zone is significantly influenced by the variables potato farming experience, education level, social participation and Extension contact affect efficiency positively while, distance to FTC affect technical efficiency negatively (Table 15).

Experience of Potato farming: Experience of the household head in potato farming had positive relationship with Technical and Economic efficiency as prior expectation significantly at 1% significance level. This implies that experienced farmers are expected were more technical efficient because they use improved variety and agricultural technology than other farmers. Potato farming experience increase by one year the potato technical and economic efficiency increase by 0.99% and 1% respectively keeping all other factors constant. This result is in conformity with the finding [26].

Education level: The coefficient for the education level had a statistically significant and positive relationship with technical and economic efficiency at 1% significant level. This is consistent with the prior expectation that those farmers that had got more education. The result implies that an additional unit of education would increase farmers' technical and economic efficiency by 1.5% and 1.7% respectively than others, keeping all other factors constant. Education enables farmers to have access to new information, ideas, knowledge and skill to use resources in more efficient ways. Positive coefficient of education means the higher the years of schooling, the higher the incidence of efficiency. Education is not only escalating agricultural productivity by increasing their understanding of modern farming techniques but also opening the mind of farmers [27].

Social participation: Membership of social participation was found to have a positive and significant influenced on technical and economic efficiency of sample potato producers at 1% and 10% level of significance respectively. Farmer who had participate in social organization were 6.1% and 4.1% more probability of technical and economic efficiency than others respectively, keeping all other factors constant. This implies that farmer participate in social organization access information provision related to price, profitability, availabilities of new technology and the provision of credit services to its members. A farmer who is member of farmer cooperative is more likely to adopt improved agricultural technologies and hence efficient in potato production than others.

Distance to FTC: Distance to farmers from Farmers Training Center of farmers had negative relationship with Technical and Economic efficiency as prior expectation significantly at 1% significance level. This implies the farmers nearby Farmers training Centers (FTC) get more information on know how to use new technologies and better management to improve their technical efficiency and economic efficiency. Farm distance to FTC increase by one kilometer the potato technical and economic efficiency would decrease by 1.3% and 1.25% respectively keeping all other factors constant. This is in line with the findings [28].

Frequency of extension contact: Frequency of extension contact was found to have a positive and significant influenced on Technical efficiency of sample potato producers at 5% level of significance. This significance indicates that for each additional extension contact potato producer farmers are more likely to produce potato efficiently than others. The result implies that an additional unit of extension contact would increase farmers' technical by 0.44% than others, keeping all other factors constant. They farmers who got the chance to more frequently visit by extension professionals are more efficient than their counter parts. Because it improves the technical knowhow and skill of the farmers thereby exchange of experience will improve the efficiency.

Dependency ratio: Dependency ratio is computed as the ratio of the number of household members aged below 15 years and those aged above 64 years to the number of household members aged from 15 to 64 years. Dependency ratio had negative relationship with Economic efficiency as prior expectation significantly at 10% significance level. The result indicates that when dependency ratio increases by unit economic efficiency would decrease by 1.7%, keeping all other factors constant. This is implied that farmers' with relatively high dependency ratio less participated in crop management that expose to high cost of production.

Table 15. *Tobit results of determinants of technical and economic efficiencies in Potato production.*

Variables	**TE**				**EE**			
	Coefficient	**Robust Std. Err**	**p>|t|**	**Marginal effect**	**Coefficient**	**Robust Std. Err**	**p>|t|**	**Marginal effect**
Constant	0.528***	0.059	0.000		0.536***	0.059		
Sex	0.018	0.037	0.620	0.0184363	-0.044	0.043	0.305	-0.044
Potato Farming experience	0.010***	0.001	0.000	0.009913	0.010***	0.0015	0.000	0.010
Dependency Ratio	-0.012	0.010	0.231	-0.012	-0.017*	0.010	0.081	-0.017
Total livestock unit	-0.0003	0.002	0.825	-0.00034	-0.001	0.0015	0.513	-0.0010
Education level	0.015***	0.003	0.000	0.015	0.017***	0.0033	0.000	0.017
Land for Potato production	-0.004	0.034	0.905	-0.0041	0.024	0.034	0.474	0.024
Participation of social group	0.061***	0.020	0.003	0.061	0.041*	0.021	0.053	0.041
Distance to FTC	-0.013***	0.005	0.010	-0.013	-0.013***	0.0045	0.007	-0.0125
Distance to market center	0.0006	0.0011	0.598	0.00057	0.0006	0.0012	0.607	0.0006
Access to credit	0.00034	0.018	0.985	0.00034	0.022	0.020	0.274	0.022
Extension contact	0.0044**	0.002	0.033	0.0044	0.001	0.0027	0.695	.0011
Non off-farm	-0.032	0.026	0.232	-0.032	-0.0078	0.0274	0.776	-0.0078
Log pseudolikelihood	143.07975				139.39554			
F(12, 105)	10.86				9.63			
Prob > F	0.0000				0.0000			
Pseudo R2	-0.6485				-0.5770			

***, **, *: implies statistical significance at 1%, 5% and 10% level respectively; Source: Survey Result, 2021

3.8. Analysis of Yield Gap of Potato Production

Productivity can change due to differences in the production technology, efficiency of the production process and environment in which production takes place. The yield gap always occurs due to TE variation among the farmers. So, analyzing of yield gap is an important system to estimate to what extent the production could be increased if all factors are controlled.

It is computed as follows:

$TE=\frac{ym}{y*m}$. Then, solving for Ym ∗, the potential yield of each sample farmer was represented as:

$*Ym=\frac{Ym}{TE}$ Where, TEm, the TE of the mth sample farmer in wheat production

∗Ym- the potential output of the mth sample farmer in wheat production in qt per ha and

Ym - the actual output of the mth sample farmer in wheat production in qt per ha Therefore, yield gap (qt per ha) = ∗Ym – Ym

In the table 16 below, it was observed that the mean potato yield difference between sample farmer due to technical efficiency variation was 31.04 qt per ha.

Table 16. *Yield gap due to technical inefficiency of potato.*

Commodity	Variable	Mean	Std. Dev.	Minimum	Maximum
Potato	Actual qt per hectare	115.89	70.502	12	538.461
	TE (%)	0.756	0.116	0.152	0.911
	Potential qt per ha	146.929	73.209	56.338	598.291
	Yield gap (qt per ha)	31.039	2.707	44.338	59.83

Survey Result, 2021

4. Conclusions and Recommendations

This chapter summarizes the whole findings of the study and makes conclusions based on the results of the descriptive and econometric model. It also highlights some important policy recommendations to enhance farmers' efficiency in potato production.

4.1. Conclusions

Improvement of agricultural productivity provides an important solution in addressing the problems of food insecurity and poverty, and enhancing the development of agriculture in Ethiopia. Potato also contributed for food security. Therefore, the analysis of technical, allocative and economic efficiency of potato farming is important. The overall objective of this study was to examine producers' technical, allocative and economic efficiencies of potato production in West Arsi of Oromia region, Ethiopia.

To conduct the study, primary data was collected from 117 randomly selected household heads through semi-structured questionnaire. Secondary data were also collected from different sources including ZOANR, DOANR, and from published and unpublished sources to supplement primary data. In this study both descriptive statistics and econometric analysis were employed. The primary data was analyzed using descriptive statistics and stochastic efficiency decomposition method to decompose TE, EE and AE. Stochastic Frontier approach (SFA) was used for its ability to distinguish inefficiency from deviations that are caused by factors beyond the control of farmers.

The descriptive analysis frequency and mean was used to analysis demographic characteristics of sample households. The result revealed that the mean TE, AE and EE was about 75.60%, 91.41% and 69.07% of for potato production. The sum of the partial elasticity of all inputs were 1.17 for Potato indicating, an increase in all inputs at the sample mean by one percent increase by 1.17% potato. This indicate that the production function is characterized by increasing returns to scale of production.

The result of Tobit model revealed that, out of total 12 explanatory variables included in the model for potato. Total of five variables found significantly determined TE and EE of potato production. To this effect, potato farming experience, education level, social participation and Extension contact affect positively while, distance to FTC affect technical efficiency negatively. The mean potato yield difference between sample farmer due to technical efficiency variation was 31.04 qt per ha.

4.2. Recommendation

Based on the findings of this study, the following recommendations are made.

Potato farming experience and frequency of extension contact positively influenced households Technical and Economic efficiency. Therefore, District office of Agriculture should be organized field days to conduct farmers experience sharing as well as frequently contact to farmers by providing technical support.

Conflicts of Interest

The authors declare no conflicts of interest.

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