

Economic Efficiency of Smallholder Farmers in Tomato Production in BakoTibe District, Oromia Region, Ethiopia

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ABSTRACT

The study is to analyze tomato production efficiencies and sources of inefficiencies differentials of tomato in BakoTibe district. It was specifically aimed to address the research and development gaps by measuring technical, allocative and economic efficiencies and their sources of inefficiency differentials of tomato in the study area. For addressing these objectives this study used primary and secondary data obtained from field survey and documents review. Multistage random sampling technique was used to draw 113 sample tomato producers. From the result, the coefficient of inputs was 1.96 which is the elasticity of production that represent first stage of new classical production function. Applying the Cobb-Douglas functional form the average technical, allocative and economic efficiencies found were 72.88%, 67.17% and 50.13% for sample tomato producers. Regarding these producers; Age of household head and education level were significant sources of technical, and economic inefficiencies. Family size and experience in tomato were also significant sources of technical and allocative inefficiencies. Sex of household head, frequency of extension visit and training given on tomato management were also significant sources of technical allocative and economic inefficiencies. For improving tomato production efficiency capacitating smallholder tomato producers through strengthening by training and frequently visiting of their farm with effective farm management will be advised.

Keywords: Bako tibe; Efficiency; Inefficiency sources; SFPF; Tobit and tomato

INTRODUCTION

Tomato is one of the most popular and widely grown vegetables in the world. It is the third largest crop after potato and sweet potato and originated in Mexico and spread throughout the world like Asia, Europe, North and South America and Africa. It is the largest fruit vegetable crop after potato and sweet potato and grown throughout the world, either outdoors or indoors, because of its wide adaptability and versatility [1-6].

In Ethiopia tomato is one of the most popular and widely grown fruit vegetables [7,8]. The crop is the most important fruit vegetable in Ethiopia and rich in vitamin B and C, iron, phosphorus, essential amino acids, sugars, etc and produced at all scales [9-12]. It used as fresh, processing (tomato paste, tomato juice, tomato ketchup and whole peel-tomato) and cherry type and income generating crop to small scale farmers as well as

provides employment in the production and processing industries [13-15]. These diverse uses make the tomato an important vegetable in the country.

Though it is contributing a lot to the Ethiopian communities, the crop is characterized by low productivity, caused by serious reliance on obsolete farming techniques, lack of knowledge on the efficient utilization of available and limited resources (especially land and capital), poor complementary services (extension, credit, marketing, infrastructure and limited use of modern agricultural technologies (fertilizer, high yielding varieties, pesticide, etc) and natural calamities are among the major factors that have greatly constrained the development of Ethiopia's agriculture [16-19].

Productivity can be increased either through introduction of modern technologies or by improving the efficiency of inputs such as labor and management at the existing technology [20,21].

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In other words, productivity can be increased through dissemination of improved technologies and/or by improving the productive capacity of farmers. To boost the productivity of tomato, Agricultural Research Centers had been made a great effort in development and dissemination of improved tomato varieties with associated agronomic and crop protection practices for the potential production areas [22].

However, the promoted technologies have not been used to full potential and no substantial gains could be achieved by using the technologies alone [23,24]. These improved technologies and improving the productive capacity of farmers shift production frontier because both are not mutually exclusive. In other word, the introduction of modern technology could not bring the expected shift of production frontier, if the existing level of efficiency is low [25].

Therefore, in order to improve tomato production and productivity it becomes vital to undertake economic efficiency analysis at farm level under the existing technology to enhance the contribution of the crop by identifying the extent of inefficiency and the factors that contribute to the level of resource use efficiency in smallholder tomato producers [21]. Such information is useful for formulating appropriate policies and for reducing the level of economic inefficiency especially in developing countries.

Moreover, there is no study done on economic efficiency of smallholder tomato producers in the study area and only limit research works were conducted in different part of the country [26,27]. Hence, there is a need to fill the existing knowledge gap by addressing issues related to technical, allocative and economic efficiencies of smallholder tomato producers in the study area on smallholder farmers resource use.

Objectives:

To estimate the level of technical, allocative and economic efficiencies of tomato producers; and

To identify the determinants of technical, allocative and economic inefficiencies in tomato production of smallholder tomato producers in the study area.

RESEARCH METHODS

Site Description

BakoTibe is located in Western Oromia at about 251 km from Addis Ababa and 80 km East of Nekemte, the zonal capital East Wollega zone. Out of the total area of the 104,452 ha, crop land accounts for 37,906 ha and the remaining land is allocated for community land, forest and other purposes. Geographically, the study area is located 370 3' 27" E longitude and 090 07' 12" N latitude and categorized into three agro-ecology like as lowland (51%), midland (37%) and highland (12%). The annual rainfall of the study area ranges of 1200-1300 mm and has an annual temperature range of 13.8-27.8 °C. The study area has total population 136,829 of which 47.1% are male and 52.9% are female. About 170 farmers were grown tomato [28].

Data Sources and Collection Methods

Both secondary and primary data were used in this study. The primary data were collected from sample households through face-to face interviews using a semi-structured questionnaire. The questionnaire included information on the socio-economic characteristics, demographic and farm characteristics, institutional supports, inputs type, amount of inputs, output and price data obtained by sample households. The secondary data which are relevant to the research topic used as additional information to strengthen the primary information provided by the sample household heads for rational conclusion.

Sampling Design and Methods of Data Analysis

For this study, BakoTibe district was selected purposively based on the presence of large number of tomato producers and its extent importance of tomato in the areas. In the second stage, four kebeles (OdaHaro, Sedan Kite, BecheraOda Gibe and Dambi Dima) were selected randomly having area under tomato and prepare list of tomato producers along with area from district. Finally, from total households about 113 samples of household heads were randomly selected from selected kebeles using probability proportionality size following a simplified formula provided by Yamane [29]. Population size is the total smallholder farmers' tomato produced in the district (N=170).

To address the objectives of the research and to analyze the data, both descriptive and Econometric methods were employed. Simple descriptive statistics (frequency, percent, minimum, maximum and mean were summarized socio-demographic, farmers, farm and inputs of sample households. For the investigation of technical, allocative and economic efficiencies, stochastic frontier production function by using Cobb-Douglas production function was used for its key features that the disturbance term is composed of two parts, a symmetric and a one sided component [30-32]. The linear Cobb-Douglas production functional form was specified as follows:

Where \ln denotes the natural logarithm; j represents the number of inputs used; i represents the i th farmer in the sample; Y_i represent the observed tomato output of the i th sample farmer; X_{ij} denotes j th farm input variables used in tomato production of the i th farmer; β stands for the vector of unknown parameters to be estimated; ε_i is a composed disturbance term made up of two error elements (v_i and u_i) and n represents the number of farmers to be involved in the survey.

The solution to the cost minimization is the basis for deriving the dual cost frontier, given the input price (w_n), parameter estimates of the stochastic frontier production function (and input-oriented adjusted output level in the following equation

The substitution of the cost minimizing input quantities yields as following dual cost function following [33-35] which is:

$$EE = \frac{C^*}{C}$$

Where, C^* is minimum cost and C is observed cost

$$AE = \frac{EE}{TE}$$

and following [36]. from $EE=TE*AE$.

For identify factors affecting technical, allocative and economic efficiencies, a censored Tobit model was used following [25,37,38]. 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 and estimation with OLS regression of efficiency score would be lead to a biased and inconsistent parameter estimate [39]. As the distribution of the estimated efficiencies is censored from above at the value 1, Tobit regression model [40] is specified as:

Where E_i is an efficiency score representing technical, allocative and economic efficiencies; $\epsilon_i \sim N(0, \sigma^2)$ and β_j are the vector parameters to be estimated; x_i represent various farm specific variables and E_i^* is the latent variable, with $E[E_i^*/X_i]$ equals $X_i \beta$.

Variables Definition and Hypotheses

Table 2: Factors affecting efficiencies of tomato production and their hypotheses.

Variables	Definition	Measurement
Output	Endogenous variable in production function and actual quantity of tomato production	Quintal
Inputs	Inputs were land, labor, oxen, fertilizers, seed and chemicals used in tomato production during the survey period	
Land	Total physical unit of land under tomato in hectare (own, rented and shared in)	Ha
Human labor	Total human labor employed in tomato production process and converted into adult-equivalent by taking into account the age and sex of labor used	MD
Oxen power	Total oxen power which used for ploughing and measured using the total amount of oxen days	OD
Fertilizers	Chemical fertilizers used for tomato production (Urea and NPS)	Kg
Seed	Physical quantity of tomato seed applied by the sample households	Kg
Chemicals	Physical quantity of chemicals such as herbicides, insecticides and pesticides applied by the sample households	Lit

Variables	Definition	Measurement	Hypotheses
Age of HH (years)	Age of sample households	Continuous	-ve
Educational level (years)	Proxy variable for managerial ability or enhanced ability to acquire technical knowledge	Continuous	+ve
Household size (N)	Total family size	Continuous	+ve
Total cultivated land (ha)	Total area cultivated during the 2016/17 production years (own, rented in or shared in)	Continuous	+ve
Tomato faming experience in year	Serve as a proxy for experience	Continuous	+ve
Frequency of extension visit (N)	Intermediate for diffusion of new and improves efficiency of farmers	Continuous	+ve
Sex of HH	Female household heads are less farming operation and use inputs less than male households	Dummy	+ve/-ve
Proximity to tomato plot (min)	The distance of plot from residence in walking minutes or km	Continuous	-ve
Livestock holding (TLU)	They could support crop production in many ways; source of cash, draft power and manure	Continuous	+ve

Off/non-farm activities	Income obtained from off/non-farm activities and it's used for purchase of agricultural inputs	Dummy	+ve
Credit utilized	It's important source of financing the agricultural activities of farmers	Dummy	+ve
Participation in training	Important tool in building the managerial capacity of smallholder farmers	Dummy	+ve

RESULTS AND DISCUSSION

Summary of output and inputs Used to Estimate the Production Function

There was variability in technical inputs and output among tomato producing farmers (Table 3). Land, fertilizer, labor, seed, oxen power and chemicals were included in production function to produce tomato output. This is economic process of producing output from these inputs or uses resources to create output that are suitable for users. On average sample households produced 151.04 quintals of tomato used 0.38ha of land, 25.40 man-days labor, 5.16 oxen-days oxen, 38.06 kg of Urea, 57.10 kg of NPS, 0.22 kg of seed and 0.92 lit of chemicals (Table 3). Chemicals used in this study are insecticides and fungicides in controlling insects and fungus which series pest in tomato production in the study area.

Variables	Unit	N	Minimum	Maximum	Mean	Std. Dev.
Output	Quintal	113	18	876	151.04	132.3
Land	Hectare	113	0.12	1.5	0.38	0.24
Labor	Man-days	113	6	165	25.4	23.79
Oxen	Oxen-days	113	1	25.5	5.16	4.09
Urea	Kilogram	113	9	200	38.06	30.51
NPS	Kilogram	113	15.5	300	57.1	45.76
Seed	Kilogram	113	0.05	1.13	0.22	0.18
Chemical	Liter	113	0.17	4.6	0.92	0.73

Source: own data (2017)

Summary of Socio-economic Variables Used in the Tobit Model

The mean age of the sample households was about 43.50 years with a range of 25 to 88 years. This means tomato producer was in their early middle age. On average tomato producing farmers

have adequate production experience which was about one year to 10 years with mean 4.64 years. The family size of the sample farmers ranged from two to 13 with a mean of 6.40 person per household. The average education level of the sample household heads during survey period was about 5.22 years with the minimum of zero year (illiterate) and maximum of 12 years (Table 4).

The minimum cultivated land holding of the sample household was 0.50 ha while the maximum size was 7.50 ha with mean 1.58 ha. The average tomato producing plot of sample household from residence 25.13 minutes with ranges from 5 to 60 minutes. On average, sample household owned livestock of 8.27 TLU ranging from 1.13 to 22.93 TLU. This indicates that the farming system in Ethiopia is mainly based on plough by animal draught power that has created complementarity between crop and livestock production (Table 4).

Regarding the sex of respondents, 91.20% of the sample households were male-headed households. This implied that the sample household headship was male. About 19.50% of sample households were participated on different types of off/no-farm activities for different purposes. The survey result showed that 85% of the sample households were received credit from input purchase and other purposes. From the total of sample household interviewed, 17.70% were received training with specific tomato production (Table 4).

Variables	Min	Max	Mean	Std. Dev.	% of N
Age of household head (years)	25	88	43.5	13	
Tomato farming experience (years)	1	10	4.64	2.28	
Educational level of household head (years)	0	12	5.22	2.83	
Household size (N)	2	13	6.4	2.75	
Total cultivated land (ha)	0.5	7.5	1.58	1.19	
Proximity to tomato plot (minute)	5	60	25.13	14.37	
Frequency of extension visit (N)	0	15	3.66	3.05	
Livestock (TLU)	1.13	22.93	8.27	5.55	

Sex of HH (1=male and 0=female)	11 3	91. 2
Off/non-farm activities (1=obtained & 0=not)	11 3	19. 5
Credit (1=received and 0=not)	11 3	85
Participation in training (1=participate & 0=not)	11 3	17. 7

Source: Own data (2017)

Econometrics Analysis

Before running the econometric models, the data was tested against econometric problems like multicollinearity using VIF, heteroskedasticity using Breusch-Pagan test and endogeneity using Durbin-Wu-Hausman chi-square test. The test results indicate that there is no problem of multicollinearity, heteroskedasticity and endogeneity in the model.

Estimation of Production and Cost Functions

The coefficients of the production function are interpreted as elasticity. The highest coefficient of output to labor (0.38) following land (0.32). This indicated that labor and land are the main determinants of tomato production in the study area. Tomato production is relatively sensitive to labor and land. If there is a one percent increase in the size of labor, land, amount of NPS, Urea, chemicals and amount of seed would increase tomato production by 0.38%, 0.32%, 0.24%, 0.29%, 0.22% and 0.23%, respectively (Table 5). In other words, the increase of these inputs were increase output of tomato production significantly which similar to the returns to scale analysis can serve as a measure of total factor productivity[41-44] and indicated that there is increasing returns to scale. This implied that there was a potential for tomato producer to continue to expand their production [45]. In other words, a percent increase in all inputs proportionally would increase the total production by 1.96 (Table 5).

Frontier variables	Parameters	Coefficients	Std. Err.
Constant	β_0	2.17***	0.14
ln(land)	β_1	0.32**	0.15
ln(labor)	β_2	0.38***	0.16
ln(oxen)	β_3	0.14	0.09
ln(Urea)	β_4	0.29***	0.08
ln(NPS)	β_5	0.24***	0.07
ln(seed)	β_6	0.23***	0.04
ln(chemicals)	β_7	0.22**	0.14

Standard error of u (σ_u)	0.18	0.01
Standard error of v (σ_v)	0.34	0.05
Sigma square (σ^2)	0.08***	0.02
Lambda ($\lambda = \sigma_u / \sigma_v$)	1.89	
Gamma ($\gamma = \lambda^2 / (1 + \lambda^2)$)	0.78	
Return to scale	1.96	

Note: *, **, *** significant at 10%, 5% and 1% level of significance, respectively. Source: own data (2017)

The value of σ^2 for the frontier of tomato output was 0.08 which was significantly different from zero and significant at 1% level of significance. The significant value of the sigma square indicated the goodness of fit and correctness of the specified assumption of the composite error terms distribution. The estimated value of gamma was 0.78 which indicated that 78% of total variation in tomato farm output was due to technical inefficiency (Table 5).

Efficiency Scores

The results of the efficiency scores indicate that there were wide ranges of differences in TE, AE and EE among tomato producer households. The result indicated that farmers in the study were relatively good in TE than AE and EE as presented in table 6.

The mean TE was found to be 72.88% which indicated that, if sample households in the study area operated at full efficiency level, households would have increased their output by 27.12% using the existing resources and level of technology. In other words, it implied that on average sample households in the study area can decrease their inputs by 27.12% to get the output they are currently getting. The majority sample households were operating ranges of 61% to 80% level of TE which indicated that there is a room to enhance their production at least by 20% (Table 6).

The mean score of AE was 67.17% showed that on average sample households in the study area could increase tomato output by 32.83% if households used the right inputs and produced the right output relative to input costs and output price. The tomato producers with an average AE would enjoy a cost saving of about 32.72% derived from $(1 - 0.6717 / 9837) * 100$ to attain the level of the most efficient producer. The majority sample households were operating ranges of 61% to 80% level of AE which indicated that there is a room to save cost production at least by 20% on average (Table 6).

Variables	TE	AE	EE
	Frequenc y	Percen t	Frequenc y
			Percen t
	Frequenc y	Percen t	Frequenc y
			Percen t

20-Oct	0	0	7	6.19		
21-30	0	2	1.77	11	9.73	
31-40	0	9	7.96	19	16.81	
41-50	7	6.19	10	8.85	14	12.39
51-60	14	12.39	19	16.81	28	24.78
61-70	28	24.78	23	20.35	13	11.5
71-80	35	30.97	24	21.24	20	17.7
81-90	20	17.7	18	15.93	1	0.88
91-100	9	7.96	8	7.08	0	
Minimum	43.57	23.81	11.87			
Maximum	99.84	98.37	84.78			
Mean	72.88	67.17	50.13			

Source: own data (2017)

The mean EE was 50.13% indicated that there was a significant level of inefficiency in the production development. That was the producer with an average economic efficiency level could reduce current average cost of production by 49.87% to achieve the potential minimum cost level without reducing output levels. It can be inferred that if households in the study area were to achieve full economic efficiency, the producers' substantial production cost saving of 49.87% (Table 6). The result also showed that the farmer with average level of economic efficiency would enjoy a cost saving of about 40.87% derived from $(1-0.5013/8478) * 100$ to attain the level of the most efficient producer. This implied that, EE could be improved significantly than TE and AE. The majority sample households were operating ranges of 50% to 60% level of EE which indicated that there is an opportunity to save cost inputs at least by 40% on behaving a cost minimizing way.

Determinants of Efficiency in Maize Production

The major interest behind measuring technical, allocative and economic efficiencies level is to know what factors determine the efficiency level of individual households[46, 47].

Variables	TE	AE	EE			
	ME	Std. Error	ME	Std. Error	ME	Std. Error
Constant	0.6046** *	0.081	0.5818** *	0.1473	0.3763** *	0.1153
AGE	0.0025**	0.0008	0.0003	0.0014	0.0127** *	0.0031

EDUCH	0.0087**	0.0032	0.0015	0.0095	0.0493** *	0.0074		
FSZE	0.0197** *	0.004	2	0.0087*	0.004	3	0.0014	0.0068
SEX	0.0582*	0.0292	0.1858** *	0.0529	0.114**	0.0414		
EXPER	0.0078** *	0.0021	0.032**	0.012	0.0057	0.0084		
OFNFA	0.0375	0.029	0.0365	0.0527	0.0052	0.0412		
CULTLN	0.0042	0.0059	0.012	0.0107	0.0038	0.0084		
CRDTR	0.0401	0.0237	0.038	0.043	0.0392	0.0337		
FEXTVST	0.0522** *	0.0051	0.011***	0.002	0.0141***	0.0027		
TRAINING	0.0578**	0.0213	0.0741**	0.0262	0.0984* 8	0.046		
PROXTY	-0.0036	0.009	-0.0051	0.018	-0.0016	0.0014		
LIVSTK	0.0013	0.0014	0.0315	0.047	0.0063	0.0037		

Source: own data (2017)

The estimated coefficient of age and education affected TE and EE positively and significant at 5% and 1% level of significance (Table 7). This implied that age and education contributed positively to TE and EE which may be because of the accumulated experiences that have been gathered over time and easily access information with better management of farming activity [48,42,38]. All these might have implied that as the level of education and age increases farmers are concerned about scarce resources and place more emphasis on increasing levels of output at a given level of inputs.

The coefficient of family size for TE and AE is positive and statistically significant at 1% and 10% level of significance (Table 7). The result showed that producers those having large family size are more efficient than those with small family size, because; they manage crop plots on time[49, 50].

Sex of household head was found to have positively and significant influence on TE, AE and EE at 10, 1% and 5% level of significance (Table 7) which indicated that female household headed were the one who responsible for many household domestic activities such as collecting of fire wood from the field, fetching water from the far distant rivers, childrearing and household management obligations and also probably use inputs fewer than male household heads[51, 52].

Years of experience in tomato production was significantly and positively affected TE and AE at 1% and 5% level of significance (Table 7). As experience increases by 1 year, levels of TE and AE increased which indicates that as years' experience increase knowledge and skill on utilizing resources and managements increases [27,53].

Extension visit and training were the number of times that the households contact with extension agents and producers received training specifically on tomato production management [54,55]. Farmers who received regular extension visits and received training by extension workers and others appear to be more technically, allocative and economic efficiencies than their counterparts. The coefficient for the access to extension visit had statistically significant and positive relationship with efficiencies at 1% level of significance whereas training had statistically significant at 5%, (TE and AE) and 10% level of significance (Table 7). This implied that efficiencies increased with the number of visits and training made to the farm household by extension workers and others due to facilitation use of modern techniques, adoption of improved agricultural production practices and use inputs in appropriate system.

CONCLUSION AND RECOMMENDATIONS

This study was focused to measure the technical, allocative and economic efficiencies of tomato growers in BakoTibe district. The Cobb-Douglas stochastic frontier result show that labor, land fertilizer and seed were significantly effect on tomato production with return to scale 1.96 which is increase return to scale. The findings of this study revealed that the technical efficiency ranges from 43.57% to 99.84% with a mean of 72.88% while allocative efficiency ranges from 23.81% to 98.37% with a mean of 67.17. The economic efficiency of tomato producers ranges from 11.87% to 84.78% with a mean of 50.13%.

Factors including sex, frequency extension visit and training were significantly effect on technical, allocative and economic inefficiencies. The results show that age and education of sample households were significantly effect on technical and economic inefficiencies while family size and tomato farming experience were significantly effect on technical and allocative inefficiencies.

On the basis of this study it is recommended that: as the coefficient of inputs was 1.96 which is the elasticity of production that represent first stage of new classical production function. Therefor the farmers in the study area needs to increase the number of inputs to increase production and efficiency, ii) in the technical, allocative and economic inefficiencies sex, extension, training and experience were found statistically significant, thus the government and other sectors needs to provide training and farming practices to improve the tomato productivity and efficiencies.

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