OPEN ACCESS

Middle East Research Journal of Economics and Management
ISSN 2789-7745 (Print) & ISSN 2958-2067 (Online)
Frequency: Bi-Monthly
DOI: 10.36348/merjem.2024.v04i01.003

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Determinants of Smallholder Farmer Maize Production Efficiency in Western Parts of Oromia in Boneya Boshe woreda, East Wollega Zone: Evidence under Shifting Cultivation Area

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Abstract: Farming in Ethiopia can offer assistance in bringing dejected needs. Hence, the best possible means of achieving growth is by increasing the production efficiency of farmers. To estimate the levels of production efficiency, this study specifically used only data from farmers who are producing without plowing by oxen and without using fertilizers in the study area under shifting cultivation. Method: To determine the determinants of production efficiency, the Tobit model was used in this study. Result. The Tobit model results show that age of household, and herbicide use had a negative impact on the production efficiency of farmers. Regarding the positive determinants of production efficiency, labor, seed, and fertilizer (NPS) have a positive influence. Conclusion and Recommendation: The farmers in the study area are efficient in the production of maize. The government should give due attention to farmers' training by strengthening farmers' education and farmer training centers to make farmers more efficient producers and profitable by integrating local and traditional knowledge of farmers with formal knowledge of using herbicides. Farmers should also be advised, as they are youngest farmers engaging in farming work. Otherwise, the government should supply fertilizer and improve seed on credit.

Keywords: Profitable, production efficiency, Ethiopia, Tobit.

Research Paper

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How to cite this paper:
Gemechu Beri & Dawit Milkias (2024). Determinants of Smallholder Farmer Maize Production Efficiency in Western Parts of Oromia in Boneya Boshe woreda, East Wollega Zone: Evidence under Shifting Cultivation Area. *Middle East Res J Econ Management, 4*(1): 15-20.

Article History:
| Submit: 13.12.2023 |
| Accepted: 12.01.2024 |
| Published: 25.01.2024 |

1. INTRODUCTION

With the increasing demand for food worldwide, how to improve agricultural production efficiency has attracted increasing attention (Xu and Zhang, 2018). In Ethiopia, maize is produced as a major food crop that is based on traditional methods of production, and there exists indecency in the use of available scarce resources (Tesema, 2022). The best possible means of achieving development is through increasing the production efficiency of farmers, and the variability in maize production efficiencies is largely due to shifting cultivation practices (Tesema, 2021).

Agriculture is the sole source of livelihood for the majority of Ethiopians. Ethiopia is endowed with enormous potential for agricultural development, and cereal crops such as maize are widely cultivated across a range of environmental conditions (Abate, 2020).

What is more, is that maize plays a significant part in Ethiopia's nutrition security and it is the staple trim with the most noteworthy generation, i.e., 4.2 million tons in 2017/18, compared to teff, which is 3.0 million tons, and sorghum which is 2.7 million tons (Kibirige, 2014). Farming in Ethiopia can offer assistance in bringing down destitution. The defenselessness of returning to destitution remains tall, especially for provincial vocations subordinate to sprinkled farming (World Bank, 2016).

Farming is more than just a job of Ethiopia's smallholder farmers, who live in a low-productivity environment (Tesema, 2022). Cultivating procedures have changed slightly over the centuries, yielding low outputs and making ranchers helpless to the impacts of eccentric climate designs (ATA, 2016; Tesfaye and Beshir, 2014).

A successful maize generation segment improvement may thrust Ethiopia's nourishment generation to rapidly diminish the national nourishment shortage and keep pace with a developing populace.

Experimental writing uncovered that fruitful maize generation depends on the proper application of generation inputs that would support the environment as well as rural generation (CIMMYT, 2018).

In Ethiopia, increasing population pressure and low levels of agricultural productivity have contributed greatly to food security problems by widening the gap between demand for and supply of food. Increasing productivity in crop production, which among others could be possible by enhancing the level of technical efficiency, is an important step toward enlightening food security (Getachew and Gemechu, 2023).

In this respect, few endeavors have been made to measure/quantify the level of specialized productivity in Ethiopia in common and especially in the Oromia region. For the little cultivates measure, the cruel specialized productivity is 0.76 (Abate, 2014). Agreeing with the maize-creating farmers' normal specialized proficiency in southern Ethiopia is 40%, while Alene and Hassan (Alene AD and RM Hassan, 2003) have shown that the maize-creating farmers' normal specialized proficiency in western Ethiopia is 76%. These results suggest that agriculturists are not working on the generation plausibility of wilderness and that there is considerable potential to extend the efficiency of maize with the existing innovations and inputs. Suboptimal rural hones oblige the capacity of ranchers to make strides in yields, and over 97% of the development is rain-fed, making the division exceedingly helpless to challenging climate designs (ATA; 2019).

Achieving broad-based economic growth requires the ability to use available resources efficiently. This requires policy interventions supported by research. By estimating the magnitude of technical efficiency gains and investigating the factors that influence the resulting level of inefficiency, this paper aims to provide a pathway to improve productivity on corn farms. Therefore, this study addressed the following research questions:

What are the determinants of the production efficiency of maize among maize producers?

Objectives of the study

- To examine and analyze the determinants of the production efficiency of maize in the Boneya Boshe District

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was conducted in Boneya Boshe District, one of the 17 districts in the East Wollega Zone of Oromia National Regional State in western Ethiopia. It is located 300 km from the capital city of Ethiopia, Addis Ababa, and 181 km away from Nekemte Town.

The agricultural system in the study area consisted of a series of interrelated crop and livestock production activities that were strongly influenced by the natural and economic environments. Crop production was the most important source of food and income for farmers. The main stable food crops grown in the study area were cereals and horticultural crops such as maize, pepper, Niger seed, sorghum, teff, and haricot beans. Livestock farming is also an important part of the agricultural system and a source of intermediate products in the study area. The large number of livestock in the study area consists of sheep, goats, cows, mules, calves, and donkeys, which are used for various purposes in addition to generating income in the study area.

2.2 Research Design

A cross-sectional survey design was used to measure current attitudes and practices. In addition, it is possible to provide information in a short period, such as the time needed for investigation and information gathering. Using a survey questionnaire, data were collected from the sample farmers of Boneya Boshe District to achieve the objectives of the study within the available time and budget.

2.3 Data Types, Sources, and Method of Data Collection

To achieve the goal of technical efficiency in maize cultivation, data were collected in quantitative and qualitative form from both primary and secondary sources. Primary data were collected from 154 households using face-to-face interviews, structured survey questionnaires, and observation methods from maize-dominant farmers, and secondary data sources were magazine articles on nature, published books, central statistical reports, and the agricultural office of Boneya Boshe District.

2.4 Sampling Technique and Sample Size Determination

Due to the importance of maize in the region and the scale of its production, Boneya Boshe woreda was specifically selected from the East Wollega zone due to its potential for maize cultivation. A two-stage random sampling technique was used to select the sample households for this study. In the first stage, out of his ten kebeles within the woreda, his three kebeles were randomly selected: Yadaa Hundaa, Yabati Girisii, and Jawis. In the second stage, his sample of 154 households from the three kebeles was selected by simple random sampling, with probability proportional to the size of maize producers in each Kebele. In this study, a simple random sampling technique was used and the population of the study area was homogeneous in terms of livelihood.

The needed sample size for the survey was computed by using a simplified formula provided by Yamane, (1969) as follows:

$$n = \frac{N}{1+N(e)2} = \frac{9865}{1+9865(0.0064)} = \frac{9865}{64.136} = 154 \ldots\ldots (1)$$

Where 'n' is the needed sample size, 'N' is the total number of smallholder farmers in the selected Kebele (9865), and 'e is the desired level of precision with the same unit of measure as the variance (e2) of an attribute in the population (in this case, e= 8).

2.5. Model Specification for Production Efficiency and Determinants of Efficiency

The stochastic frontier model was employed to estimate the parameters of production function and the level of efficiency. This is because this technique accounts for measuring inefficiency factors and technical errors occurring during measurement and observation [15]. To take into account the effects of these errors, the stochastic frontier model was used in this study. Following Aigner et al. [16] and Meeusen and van Den Broeck [17], the stochastic frontier model defined below was adopted for this study:

$Y_i = F(xi\ \beta) + vi - ui \ldots i=1,2\ldots N$ ………………. (2)

Where Y_i measures the quantity of maize output of the i^{th} farm in the Boneya Boshe district, X_i is the vector of input variables used by the i^{th} farmer in the lowland area such as land, labor, and seed used by the sample household.

β is the vector of unknown parameters. The functional specification F(xi β) is a proper production function (Cobb–Douglas). The disturbance term is intended to capture the effects of the stochastic noise and it is assumed to be vi~N (0, δ^2). The disturbance, ui, captures the technical inefficiencies.

Production efficiency from the stochastic production frontier was regressed using a censored Tobit model on farm-specific independent variables that show disparities in efficiency across farms. Tobit regression [18] is specified as:

$E^*=\delta_0+\delta_m Z_{im}+\mu$, ……………… (3)

$\frac{v}{z} \approx$ Normal (0, δ^2), …………… (4)

Where E* is a latent variable representing the efficiency scores of maize producer farmers. δ is a vector of unknown parameters to be estimated. Z_{im} is a vector of explanatory variables m (m = 1,2,…,n) for farm households such as X1 = Age of household I years. X2 = education levels in years of schooling. X3 = family size in number. X4 = sex of household in dummy (1 if male, 0 if female heeded household). X5 = farm size in hectare. X6 = livestock holding in tropical livestock unit. X7 = Seed measured in kg X8 = fertilizer (NPS in kg), X9 = fertilizer (Urea in kg). X10 = chemical (pesticide in kg). X11 = chemical (Herbicide in kg), X12 = labor in per day equivalent. X13 = off-farm income dummy (one if farmers engaged in off-farm activities, zero if not). μ is the error term that is independently and normally distributed with zero mean and variance δ^2.

Denoting E_i as observed variables,

$$E_i = \begin{Bmatrix} 1, if\ Ei * \geq 1, \\ 0, if\ Ei * \leq 0, \end{Bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Following McDonald and Moffitt [19] from the likelihood function decomposition of marginal effects, the two-limit Tobit model is as follows:

The unconditional expected value of the dependent variable is given by

$$\frac{\partial E(y)}{\partial Xj}=[\varphi(Zu) - \varphi(Zl)] * \frac{\partial E(y*)}{\partial x} + [\varphi(Zu) - \varphi((Zl)] \frac{\partial}{\partial Xj} + \frac{\partial[1-\varphi(Zu)]}{\partial Xj} \ldots\ldots\ldots (6)$$

Where $\varphi(.)$ is the cumulative normal distribution, $\emptyset(.)$ is the normal density function, Z_L = and Z_u = are standardized variables that came from the likelihood function given the limits of y, and σ is the standard deviation of the model.

2.6 Method of Data Analysis

Concerning data analysis both descriptive and econometric methods were employed. Descriptive statistics such as the mean, standard deviation, percentage, and frequencies could be used to analyze the socio-economic characteristics of maize producers. A Tobit econometric model was employed to analyze the determinants of maize production efficiency in the study area.

3. RESULTS AND DISCUSSION

3.1 Descriptive statistics for continuous variables in the study

A combination of different descriptive, mean, and standard deviation and inferential, t-test, and X^2-test, statistics for explanatory variables of sample households were performed on the household level data to inform the subsequent empirical data analysis.

The mean education level of the households was 4.58. The mean family size of the household head was approximately 6.00, the mean ownership of land was 1.52 hectares, the mean seed in quintal was 30.46 per hectare, the mean fertilizer (NPS) application rate was 37.64 per hectare, the mean fertilizer (Urea) application rate was 67.21 per hectare, the mean usage of pesticide was 2.39 per hectare, the mean herbicide usage was 2.64 per hectare and the mean livestock holding of the farmers was 12.00 as presented in Table 1.

Table 1: Descriptive statistics for continuous variables

Variable	Mean	Std. Dev.	Min	Max
Labor	2.68	1.87	1	6
Education	4.58	2.83	0	10

Variable	Mean	Std. Dev.	Min	Max
Family Size	6.00	2.66	1	13
Ownership land	1.52	0.87	1	4
seed	30.46	10.96	20	50
Fertilizer (NPS)	37.64	32.98	25	120
Fertilizer (Urea)	67.21	46.22	25	150
Pesticide	2.39	6.18	2	5
Herbicide	2.64	3.79	1	5
Livestock holding	12.00	8.72	0	45

***Source**: computed from survey data*

3.2 Descriptive statistics for dummy variables in the study

The descriptive and inferential statistics results presented in Table 2 show that 64.94% of maize producer farmers were male-headed households.

Table 2: Descriptive statistics of discrete variables

Sex of household head	Freq.	Percent
Female	54	35.06
Male	100	64.94
Total	**154**	**100.00**

***Source**: Field survey, 2021*

3.3 Determinants of Maize Production Efficiency and Its Marginal Effects

Table 3 presents the results of the censored Tobit model regression of selected socioeconomic and institutional support factors against farm production efficiency scores. Among the selected variables, Own land, livestock holding, sex of Household, Education of Household, Family Size, fertilizer (Urea), and Pesticide visit were not significant, while the others were significant determinants of maize production efficiency.

The result presented in the table below shows that household labor has a positive coefficient, and significantly affects production efficiency at the 10% level. The result shows that a one-unit increase in labor increases the level of production efficiency by 15.09%. As labor increases, their ability to produce appropriately increases. The results show that the age of the household has a negative coefficient, and significantly affects production efficiency at the 5% level. The result shows that a one-year increase in the farmer's age reduces the level of production efficiency by 3.05%. As the age of farmers increases, their ability to allocate resources appropriately decreases. However, this does not mean that as the age of farmers in the working age group increases, their ability to allocate resources for production efficiently decreases. As their age increased their ability to allocate farm input also increased until they became out of the working age group and became tired, and then decreased. The increase in seed provision by the government by 1 kg increases the production efficiency of maize by 2.74%. This result indicates that improved seeds support the yield increase and there by the production of maize. The results show that the use of 1 kg NPS (inorganic fertilizer) increases the production efficiency of maize by 0.82%. This finding suggests that the application of NPS fertilizer improved the nitrogen and phosphorus use efficiency of maize compared to the previously recommended NP. Increasing herbicide usage by 1 liter decreases the production efficiency of maize. This might be because of not using the right dozen amounts of herbicide and not using the right time application. Therefore, this situation has reduced the production efficiency of maize in the study area.

Table 3: Determinants of production efficiency and its marginal effects

Determinants of production efficiency	Coefficients	Standard error	Marginal effects	Standard error
Own land	0.0807	0.1515	0.0807	0.1516
Labor	0.1509*	0.0789	0.1509	0 .0790
Age of Household	-0.0305**	0.0091	-0.0305	0.0091
sex of Household	0.0496	0.2882	0.0496	0.2882
Education of Household	-0.0158	0.0509	-0.0158	0.0509
Family Size	- 0.0638	0.0594	-0.0638	0.0595
Seed	0.0274*	0.0128	-0.0274	0.0128
Fertilizer (NPS)	0.0082*	0.0036	0.0081	0.0036
Fertilizer (Urea)	-0.0008	0.0033	-0.0008	0.0033
Pesticide	-0.0222	0.0142	-0.0222	0.0143
Herbicide	-0.0506*	0.0215	-0.0506	0.0215
TLU	-0.0084	0.0137	-0.0083	0.0138

Determinants of production efficiency	Coefficients	Standard error	Marginal effects	Standard error
off-farm Income	0.0397	0.2878	0.0397	0.2879
_cons	6.3554	0.9748		

***Source**: own survey data, 2021.* *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

4. CONCLUSION AND RECOMMENDATIONS

The study concluded that maize farmers in the study area were not completely efficient in their production activities, and this efficiency of maize needs to be increased altogether. The Production efficiency of maize was significantly affected by the age of the household, labor, seed, NPS (inorganic fertilizer), and herbicide.

Based on the findings of the study, it is prescribed that the expansion of extension service experts should focus on training the farmers on improved production management to enable them to use the existing resources efficiently and increase the productivity of maize. The government should give due attention to farmer training by strengthening farmers' education and farmer training centers to make farmers more efficient producers and profitable by integrating local and traditional knowledge of farmers with formal knowledge of using herbicides. Farmers should also be advised as the youngest farmers engaging in farming work. Otherwise, the government should supply fertilizer and improve seed on credit.

Data Availability: Data will be made available on request.

Author Contribution Statement: Both authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by Gemechu Beri Abdeta and Dawit Milkias Kebede. The first draft of the manuscript was written by both, and who also commented on previous versions of the manuscript. All the authors have read and approved the final manuscript.

Competing Interest: The authors have declared that no competing interest exists.

Acknowledgements: We would acknowledge Jimma University and Ethiopian Institute of Agricultural research (EIAR) Head Office due to their official assistances and supports budget during data collection survey.

ETHICAL DECLARATIONS

Conflict of Interest: The authors have no conflicts of interest to declare concerning for this article.

Ethical Approval and Consent to Participate

Before data collection, the authors requested an official support letter from the university that explained the overall purpose of the study to all concerned district offices, and then the researcher got the consent of all households to supply the required data for the study. The data obtained from respondents was kept confidential and used for academic purposes only. The primary data obtained from each respondent was kept confidential and agreed upon by the respondents to be used for academic purposes only. Finally, all participants, including survey enumerators, supervisors, and key informants, were provided adequate training for survey administration.

Consent for Publication: Each of the authors has permitted the manuscript to be published.

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