Journal of Development and Agricultural Economics

Volume 7 Number 8 August 2015
ISSN 2006-9774

ABOUT JDAE

The Journal of Development and Agricultural Economics (JDAE) (ISSN:2006-9774) is an open access journal that provides rapid publication (monthly) of articles in all areas of the subject such as The determinants of cassava productivity and price under the farmers' collaboration with the emerging cassava processors, Economics of wetland rice production technology in the savannah region, Programming, efficiency and management of tobacco farms, review of the declining role of agriculture for economic diversity etc.

The Journal welcomes the submission of manuscripts that meet the general criteria of significance and scientific excellence. Papers will be published shortly after acceptance. All articles published in JDAE are peer-reviewed.

Contact Us

Editorial Office: jdae@academicjournals.org

Help Desk: helpdesk@academicjournals.org

Website: http://www.academicjournals.org/journal/JDAE

Submit manuscript online http://ms.academicjournals.me/

Editors

Editorial Board

Journal of Development and Agricultural Economics

Table of Contents: Volume 7 Number 8 August 2015

ARTICLES

Research Articles

academicJournals

Vol. 7(8), pp. 273-281, August, 2015
DOI: 10.5897/JDAE2015. 0653
Article Number: D74A6D154349
ISSN 2006-9774

http://www.academicjournals.org/JDAE

Journal of Development and Agricultural Economics

Full Length Research Paper

Socio-economic factors affecting adoption of early maturing maize varieties by small scale farmers in Safana Local Government Area of Katsina State, Nigeria

Ndaghu Ndonkeu Nathanel[1]*, Zakari Abdulsalam[1], Shehu Abdul Rahman[1] and Tahirou Abdoulaye[2]

[1]Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University Zaria State, Nigeria.
[2]International Institute of Tropical Agriculture, Ibadan, Oyo State, Nigeria.

Received 4 April, 2015; Accepted 23 June, 2015

This paper examined the socio-economic factors affecting early maturing maize varieties adoption in Safana Local Government Area of Katsina State, Nigeria. Using random sampling techniques, 300 maize farmers were selected across 10 communities in the Local Government area. Out of the 300 respondents sampled 163 were non-adopters and 137 were adopters. Data obtained were analyzed using descriptive statistics, adoption index and Probit regression models. The major findings showed that 88% of respondents were male headed, average age of household head was 44 years, average household size was 11 persons, dependency ratio was 1.49, level of education was Islamic education, average years of schooling was 5 years and average years of farming was 25 years. About 65% of farmers had access to extension agent, only about 10% had access to credit and labor force was mostly family labor. Results of probit model showed that farmers' size of land for maize cultivation (1%), farmers' participation in an association (1%), number of extension contacts (10%), age of farmer (5%) and income from sales of maize (1%) influenced the adoption of early maturing maize varieties. The adoption of early maturing maize varieties has contributed in increasing the income of maize farming households as well as enhancing the status of maize farming households.

Key words: Socio-economic factor, adoption, early maturing maize varieties.

INTRODUCTION

Maize is a major cereal and one of the most important food crops in Nigeria. It is one of the major crops grown in Katsina State. Its genetic plasticity has made it the most widely cultivated crop in the country, from the wet evergreen climate of the forest zone, to the dry ecology of the Sudan savanna. Being photoperiod sensitive, it can be grown anytime of the year giving greater flexibility to fit into different cropping patterns. It is one of the most

*Corresponding author. E-mail: nnathaliie@yahoo.com, Tel: +2347030085091.

dominant cereal crops in the southern and northern Guinea and Sudan savannas (Onyibe et al., 2006). Trends in maize production indicate a steady growth, mostly due to the expansion of cultivated area, but also the result of early maturing maize yields. In 1989 to 1991, the average maize yield in Africa of 1.2 tons per hectare was twice that estimated for the 1950s, before improved varieties were generally available (Byerlee and Heisey, 1997). In the last 20 years widespread adoption of early maturing maize varieties in the savannas means that maize is no longer a backyard crop but a major cereal grown for both cash and food (Eckebil, 1994; Fajemish, 1994; Smith et al., 1997). The development and promotion of quality protein maize (QPM), a high lysine type of maize that can improve the nutrition, particularly for women and children in places where maize comprises the major source of protein in human diets. QPM also boosts the productivity of monogastric farm animals (poultry and swine) when used in feeds, and is valuable where farmers cannot afford or obtain lysine supplements for feed (Reynolds et al., 2008). Maize therefore has a considerable potential to enhance food security and the productivity and sustainability of the crop-livestock system (Arege et al., 2006).

However, despite the potential for further yield increases, maize production faces numerous problems including poor soil fertility, *Striga*, disease, drought, low and erratic rainfall, and long dry season (Tambo and Abdoulaye, 2011). Over years the International Institute of Tropical Agriculture (IITA) has in collaboration with national partners developed and disseminated a number of early maturing maize technologies that meet the requirement of their major clients and small-scale farmers in northern Nigeria and West Africa savanna at large.

IITA has made significant advances in improving the productivity of maize, by developing a number of improved varieties with generally high grain and yields, resistance to major insects, pests and diseases (Alene and Manyong, 2007). Several of these varieties have been released in Nigeria but are not widely disseminated in northern Nigeria including Katsina State. Baseline studies carried out by Ayanwale et al. (2013) shows limited adoption of improved technologies in Katsina State, and about 26% of the sampled farmers in Safana local government area were aware of early maturing maize varieties but zero percent has adopted citing unavailability of the seeds. Despite the development of a large number of early maturing maize varieties, farmers in northern Nigeria including Katsina State have continued to grow predominantly local varieties (Tarawali and Kureh, 2004). The limited use of improved varieties in a predominantly maize growing region may be due to several factors; lack of information on early maturing maize varieties, unavailability of seed, or the unacceptability of new varieties due to low market values or unsuitability for the farming system (Ellis-Jones, 2009).

In order to reduce these constraints to crop production in Katsina State, the Sudan Savanna Task Force of the KKM PLS project was funded by the Forum for Agricultural Research in Africa (FARA) and led by IITA in collaboration with IAR and other collaborative bodies to disseminate improved agricultural technologies in the State. The objective of this paper was to collect information on socio-economic factors influencing adoption of early maturing maize varieties.

METHODOLOGY

Study area

This study was conducted in Safana LGA Katsina State, Nigeria. Safana Local Government Area(LGA) has a projected population of about 183,779 based on 3.2% growth rate (NPC, 2006) and an area of 282 km^2 (KTARDA, 2012). The Local Government is located at 12° N and 7°E of the equator. April is warmest with an average temperature of 37.9°C at noon. December is coldest with an average temperature of 13°C at night. Safana has no distinct temperature seasons; the temperature is relatively constant during the year.

Sampling procedure

The target populations for this study were male and female maize farmers from all the 10 communities of the Sorghum/Legume/Livestock platform in Safana LGA. These communities are Mai Jaura, Kunamawa A, Kunamawa B, Dogon Ruwa, Kanbiri, Sabon Garin Baure, Sabon Garin Gamji, Doga, Takatsaba, Kwayawa. There was no complete list of farmers in these communities but a list of maize farmers was generated with the help of both the village heads and extension agents in these communities. From each of the ten communities, 30 respondents were randomly selected giving a total of 300 respondents. Out of the 300 respondents sampled 163 were non-adopters and 137 were adopters.

Data collection

Primary data were used for this study. Data were collected using structured questionnaire administered by trained enumerators. The information collected was on sex, age, marital status farm size and family size based on 2012 farming season. The survey was conducted in March 2013.

Data analysis

The analytical tool that was employed for this study was probit regression model. The specification of the probit model follows that in the process of planting early maturing maize varieties, farmers have to decide between two choices, and if *Y* is the outcome from the choice, then:

Y_i = 1, if the farmer plants the early maturing maize varieties introduced.
Y_i = 0, if the farmer does not plant the early maturing maize varieties introduced

Either choice yields a utility index, U_i, that the individual farmer, *I*, acts to maximize. If U_i^* is the critical or threshold level, at which decision to plant occurs, then:

$Y_i = 1$ if $U_i > U_i^*$
$Y_i = 0$ if $U_i \leq U_i^*$ (1)

The non-observable underlying utility function which ranks the preference of the *ith* farmer can be expressed thus:

$$\sum_{n=1}^{N} Bn\ Xni\ ei \quad (2)$$

Where, Xni = the nth variable of the *ith* observation and Bn = the nth parameter to be estimated.
The probability Pi for the farmer i to adopt the varieties is then:

$P_i = P [Y =1] = P [U_i > = U_i^*] = P [U_i^* < = U_i]$

Since U_i^* is a discrete random variables, if F [*] is its cumulative distribution function, then:

$P [Y = 1] = P [U_i^* < = U_i] F [U_i]$
$P[Y-1] = 1 – F [U_i]$ (3)

The form of F [*] is determined by the probability density function of the random variable U_i. Equation [ii] is a form of generalized linear models which can be rewritten as follows:

The Linear form of the model is specified as:

$$Y_i = α + β_1X_1 + β_2X_2 + β_3X_3 + β_4X_4 + β_5X_5 + β_6X_6 + β_7X_7 + β_8X_8 + β_9X_9 + μ \quad (4)$$

X_1 = Age of the farmer (in years)(-); X_2 = Years of formal education (+); X_3 = Number of years of farming experience (+); X_4 = Previous season farm income for maize (Naira) (+); X_5 = Farm size (hectares cultivated for maize per season) (+); X_6 = Access to credit (Amount of credit accessed during production season) (+); X_7 = Extension contact (Number of extension contacts during the production period) (+); X_8 = Household size (number of person in the household) (+); X_9 = membership of association (Years spent in association) (+); α = constant term; μ = disturbance term or error term, and $\beta_{1,}.\beta_9$ are the regression coefficients of the independent variables.

RESULTS AND DISCUSSION

Socio-economic characteristics of maize farmers

A summary of demographic data is provided in Table 1. It examined the distribution of respondents by gender, age, household size, education, farming experience, extension contacts, sources of information, membership of association, credit facilities and labor force.

Gender

The result of the analysis showed 88% of households were headed by males and 12% were female headed in the study area. The result is in agreement with findings of Yanguba (2004) who reported that 96% of farm households surveyed in Katsina State were male headed. Mbavai (2013) reported similar trend in a study of cowpea farmers in Musawa LGA of Katisna States. This result shows that men are more involved in maize farming. Because of the influence of tradition and religion women are generally restricted to their compounds.

Age

Results from the study show that majority of the farmers were between the ages of 35-54. Thirty-six percent of the respondents were aged 35-44 years while 32.7% were aged 45-54%. The average age of respondent was 44 years. Idrisa (2009) reported 40 years as active age of farmers for farm households in Southern Borno, Nigeria. This result agree with those of Mbavai (2013), Idrisa (2009), Kamara (2009), Akudugu et al. (2012), Mignouna et al. (2013) which showed the farming population in the study area and that of northern Nigeria generally is relatively young. This means that there is an active labor force available for farming.

Household size

Result from the study shows that about 80% of responding households had not less than nine members. The average household size in the study area was 11 persons per household. Household size determines the available human labor force that can be employed in carrying out crop production activities. Agwu (2004) in his work discovered an average of seven people per household, Amos (2007) found average household size to be nine persons; Idrisa (2009) in his findings recorded an average of seven persons while Mignouna et al. (2013) in his result documented an average of nine persons per family. According to them, household size determines the availability of household labor supply.

Dependency ratio

The result from this work showed the dependency ratio of 1.49. This implies that there are more dependents (children below 15 years old and adults above 64 years old) compared to adults (>15 years and <64 years old) in the study area. This finding is in-line with Mignouna et al. (2013) whose result showed a dependency ratio of 1.29 and they concluded that the sampled population in their study area was more dependents.

Education

The result shows that 14% of the respondents had no formal education, 12.3% had primary school education, 10.3% had secondary school education, 3.7% had tertiary education and Islamic education had 59.7% which is the highest. Education increases the ability to assess, interpret, and process information about a new technology, enhancing farmers' managerial skills including efficient use of agricultural inputs. From the result majority of

Table 1. Socio-economic characteristics of respondent farming households.

Variables	Adopters	Non-adopters	Pooled
Male-headed households (%)	92.7	84.0	88.0
Age			
<24	0.6	-	0.3
25-34	8.6	14.6	11.3
35-44	37.4	34.3	36
45-54	31.1	34.3	32.7
55-64	14.1	13.1	13.7
>65	8.0	3.6	6
Age of household heads (Average)	42	43	44
Average Household size	9	13	11
Dependency ratio	1.36	1.61	1.49
Level of education (%)			
No formal	11.7	16	14
Primary	12.4	12.3	12.3
Secondary	13.9	7.4	10.3
Tertiary	5.1	2.5	3.7
Islamic	56.9	62	59.7
Average years of schooling	6	5	5
Years of farming experience (%)			
1-10	16.1	17.8	17
11-20	35	29.4	32
21-30	24.1	25.4	24.7
31-40	19	21.8	20.6
41-50	5.8	5.8	5.7
Average years of farming	25	24	25
Contact with extension agent (%)			
Contact	86.9	68.1	76.67
No Contact	13.1	31.9	23.33

respondents had Islamic education. This is due to the fact that the study area is a predominantly Muslim community where Islamic knowledge is given a high priority. The low level formal education in Safana LGA might limit adoption of the technology. This result contradict the results of Bonabana-Wabbi (2002) in Uganda, Jones (2005) in Togo-Benin, Muyange (2009) in Kenya, Kudi et al. (2011) in Kwara (Nigeria) who reported high level of formal education among households in their study areas. High level of formal education in a study area would mean that majority of farmers are expected to accept new technology within a relative shorter period of time.

Farming experience

The distribution of respondents based on years of farming experience shows that 17% of maize farmers in the study area had experience in maize production from 1 and 10 years, 32% had been producing maize for eleven and twenty years, 24.7% had experience for twenty-one to thirty years, 20.6% had experience for thirty-one to forty years and 5.7% had experience for more than forty-one years. The mean years of experience for the farmers were 25 years. This implies that majority of maize farmers had long period of farming experience and therefore would be conversant with constraints to increased maize production. Yanguba (2004) found similar result in his work that farmers in Katsina had 24 years farming experience. Bello et al. (2012) found out that most (83.70%) of the respondents in Jenkwe Development Area of Nasarawa State, Nigeria had above 10 years of farming experience. Years of experience in farming were important because management skills of farmers improved with experience.

Contact with extension agents

The result in Table 1 showed that both adopters and non-

Table 2. Classification of responses based on sources of information on early maturing maize varieties.

Sources of information	Adopters	Non-adopters	Pooled
0	4(2.9)	32(19.6)	36(12.0)
1	0	1(0.6)	1(0.3)
1, 2	11(8.0)	19(11.6)	30(9.9)
1, 2, 5	2(1.5)	3(1.8)	10(3.3)
1, 3	5(3.6)	4(2.4)	5(1.6)
1, 3, 5	5(3.6)	2(1.2)	9(3.0)
1, 5	9(6.5)	10(6.1)	7(2.3)
1, 2, 3	5(3.6)	5(3.1)	19(6.3)
2	3(2.2)	7(4.3)	11(3.6)
3	24(17.5)	5(3.1)	29(9.7)
3, 5	0	2(1.2)	3(1.0)
4	3(2.2)	1(0.6)	4(1.3)
5	5(4.4)	7(4.3)	13(4.3)
6	58(42.3)	65(39.9)	123(41.0)
Total	137(100)	163(100)	300(100)

0=no response, 1=market visit, 2=TV/Radio, 3=other farmers, 4=middlemen, 5=friend/relative, 6=extension agents. Figures in parenthesis are percentages.

adopters had contact with extension agents to a percentage greater than 60%. About 86.9% of the adopters had contact with an extension agent while 13.1% had no contact with extension agents. About 68.1% of non-adopters had contact with extension agents while 31.9% did not. Farmers must have information about the intrinsic characteristics of improved varieties before they can consider planting them or not. Ayayi and Solomon (2010), Ede (2011), Gama (2013) found that about Fifty-Three percent and above of the respondents in their study area had contact with extension agents.

Sources of information on early maturing maize varieties

The result on Table 2 reveals that majority (41%) of farmers got the information on early maturing maize varieties from extension agents. The impact of this information on farmers' decisions varies according to its channel, sources, content, motivation and especially, frequency of visit. Also, it could be due to the various interventions received by Safana LGA through different Governmental and Non-Governmental Organizations. Adesope et al. (2012), Ango et al. (2013) found in their study that respondents (farming households) had good source of information on agricultural technologies.

Membership of association of early maturing maize varieties farmers

Analysis on Table 3 shows the distribution of respondents based on membership of associations. Obviously, the percentage of membership was higher among the adopters (72.1%). About 46.6% of the non-adopters had nothing to do with an association. The average years spent in an association was five years for adopters and three years for non-adopters. The overall mean number of years respondents were registered as members of an association was 4 years. Membership of an association enables farmers to interact with other farmers, share their experiences and assist themselves. Interaction of farmers with other farmers is an avenue through which innovation diffusion can occur. According to Oboh et al. (2006) membership of an association or any farming group is a strong determinant of adoption of cassava varieties in Benue State.

Table 3. Membership of association of early maturing maize varieties farmers.

Variable	Adopters	Non-adopters
Member	99(72.3)	87(53.4)
Non Member	38(27.7)	76(46.6)
Total	**137(100)**	**163(100)**

Figures in parenthesis are percentages.

Credit facilities on early maturing maize varieties

The result presented on Table 4 shows that only 11.7% adapters had access to credit and 10.4% for non-adopters. The importance of agricultural credit in

Table 4. Access to credit on early maturing maize varieties.

Variable	Adopters	Non-adopters
Yes	16(11.7)	17(10.4)
No	121(88.3)	146(89.6)
Total	**137(100)**	**163(100)**

Figures in parenthesis are percentage.

Table 5. Labor force on early maturing maize varieties.

Variables	Adopters	Non-adopters
Family labor	68(49.6)	63(38.7)
Hired labor	16(11.7)	60(36.8)
Family and hired labor	53(38.7)	40(24.5)
Total	**137(100)**	**163(100)**

Figures in parenthesis are percentages.

production cannot be over emphasized. It increases the purchasing power of farmers and adoption of improved technology. The study observed that the crop farmers in the study area used different amounts of credit to finance their production activities. Results from this study showed that very few farmers have access to credit which may limit their ability to expand production of maize. This finding agrees with Idrisa (2009), Ayayi and Solomon (2010), Adesope et al. (2012) found out that credit availability was very essential for agricultural productivity.

Labor force on early maturing maize varieties

The result on the Table 5 indicated that about 49.6% of adopters and 38.7% of non-adopters used only family labor, while about 11.7 and 36.8% employed solely hired labor for adopters and non-adopters respectively, and 38.7 and 24.5% combination of family and hired labor respectively. The crop farmers were distributed based on the source of human labor employed in their crop production process. This further explains why household size is large.

Factors influencing the adoption of early maturing maize varieties

Nine variables were hypothesized to influence the probability of farmers' adoption of early maturing maize varieties as showed on Table 6. These factors are age of household head, education level of household head, household size, farm size, years of farming experience, membership of an association, number of extension contacts, amount of credit, and previous farm income for maize.

Out of the variables hypothesized to influence the probability of farmers' adoption to early maturing maize varieties, five were found to be significant at 1, 5 and 10% probability levels. These variables include farmers' size of land for maize cultivation, farmers' participation in an association, number of extension contacts, age of farmer and income from sales of maize.

The role of a farmer's age in explaining technology adoption has been controversial. In this study, age of farmer was negative and significant at 5% level of probability, suggesting that the older the farmer, the lesser his adoption level. Younger farmers are likely to take up new technology than older farmers being that they are risk bearers in decision making, less responsibility and more adventurous than older farmers. On the other hand, it may be that older farmers may have extra resource that makes it more likely for them to try new technologies. This result is similar to the findings of Muyanga (2009) and Yanguba (2004), which suggest that older people are sometimes thought to be less amenable to change and hence reluctant to change their old ways of doing things. In this case, age is expected to have a negative impact on adoption. On the other hand, older people may have higher accumulated capital, more contacts with extension and preferred by credit institutions predisposing them more to technology adoption than younger ones. This is in-line with Kamara (2010) who found in her study that the adoption of soybean in Borno State was positively influenced by female farmers suggesting that younger women are less involved in farming thereby limiting their participation in project activities.

The estimated parameter for income was significant at 1% probability level and it was positive. This implies that the higher the income of respondent, the higher their level of adoption. The more famers adopt early maize varieties, the more the sales and income they will get and invariably, the better their standard of living. This finding is in line with Bello et al. (2012) who confirmed that the positive relationship between income and adoption of Crop-Based Technologies. This implied that availability of income enhanced farmers' ability to purchase the inputs embodied in the new technology and paid for hired labor needed for the use of these inputs and improved management practices for greater productivity.

The parameter estimate for farmers' contact with extension agents was found to be positive and significant at 10% level of probability. This implies that farmers who had more interactions with extension workers adopted more of the early maturing maize seeds as production technology compared to farmers who had less interaction with extension agents. Increased frequency of interaction between extension agents and farmers results in better technical support received by farmers. This greatly increases farmers' knowledge of the benefits of technologies. Hence, it can motivate farmers into using more of the technology. This is in-line with the findings of

Table 6. Factors influencing the adoption of early maturing maize varieties.

Variables	Coef.	Std. Err.	Z	P>|z|
Educational level of farmer	0.20009	0.05722	0.35	0.727
Age of farmer	-0.29155**	0.14038	-2.08	0.038
Income	0.02342***	7.59	2.79	0.005
Household size	0.004197	0.01457	0.29	0.773
Farming experience	0.016099	0.01292	1.25	0.213
Number of extension contacts	0.078975*	0.044	1.79	0.073
Years of Participation in an association	0.074580***	0.02271	3.28	0.001
Amount of credit	-2.04	0.000012	-0.02	0.986
Size of farm	3.04290***	0.36916	8.24	0.000
Constant	0.03640	0.80978	0.04	0.964
Log likelihood	-142.88251			
Pseudo R^2	0.3091			

***P<0.01; **P<0.05, *P<0.10.

Ebojei et al. (2012) which also suggested that participation in hybrid maize could be motivated by frequent contacts with extension agents. Extension agents popularize innovation by making farms exchange idea, experiences, and make it cheaper to source information, knowledge and skills in order to enable farmers to improve their livelihood. Farmers who have frequent contacts with extension agents had a higher probability of participation in the innovation. This was presumed; as farmers were privileged with materials and managerial support, followed by cheap and timely availability of knowledge and skills, which apparently helped them, apply new technology.

Membership in an association was found to be positive at 1% significant level of probability. This implies that membership in an association will lead to an increase in adoption of early maturing maize varieties. The membership of social organizations and cooperatives enhances the interaction, exchange and cross-fertilization of ideas among farmers. Hence, it offers an effective channel for extension contact with large number of farmers as well as opportunities for participatory interaction with extension organization. This result is similar to that obtained by Zavale et al. (2005) which says that membership of organization or cooperative indicates the intensity of contacts with other farmers. Kamara (2010) also found out that membership of an association was significant in influencing the adoption of improved soybean production among male and female farmers in Borno State. Farmers who do not have contacts with extension agents may still be informed about new technologies by their peers.

Farm size was also found significant at probabilistic level of 1%. This variable is expected to have positive relationship with farmers' adoption decisions. Farmers with larger farms will be more willing to devote portion of the land to an untried variety compared to those of smaller farms. This is because the lager the farm size cultivated the higher the tendency to adopt. Therefore farm is expected to have a positive impact on adoption. The farm size influences households' decision to adopt or to reject new technologies. Hence, land holding was hypothesized to have positive and significant relationship with adoption and intensity of adoption. The finding corresponds with that of Kamara (2010) and Bamire et al (2010). Feeder et al. (1985) in Ebojei et al. (2012), assert that, the positive and significant coefficient of farm size indicates its positive influence on participation in technology adoption. They said it may be because the farm size is a surrogate for a large number of factors such as size of wealth, access to credit, capacity to bear risk, access to information and other factors.

Farming experience, household size and educational level of farmer, amount of credit had no significant influence on the adoption of early maturing maize varieties in the study area.

In this study, it was hypothesized that there is no significant relationship between adoption of early maturing maize varieties and socio-economic characteristics of farmers. This hypothesis was examined by testing the variables using the probit regression model. The result of the probit model shows that five (5) were found to influence the probability of farmers' adoption to early maturing maize varieties. This implies that the null hypothesis which states that there is no significant relationship between the adoption of early maturing maize varieties and socioeconomic characteristics of farmers will be rejected.

Conclusion

The main factors are age of household head, farm size, membership of an association, number of extension contacts, and previous farm income for maize. The adoption of early maturing maize varieties has contributed in increasing the income of maize farming households as well as enhancing the status of maize farming households and this suggests that the adoption of early maturing maize varieties by maize farming households was very instrumental in enhancing the income and well-being of the maize farming households.

Conflict of Interest

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENTS

The staffs of Socio-Economic Unit (IITA) Ibadan are highly appreciated. This project was funded by the Forum for Agricultural Research in Africa (FARA) and led by IITA in collaboration with Institute for Agricultural Research (IAR).

REFERENCES

Adesope OM, Matthews-Njoku EC, Oguzor NS, Ugwuja VC (2012). Effect of Socio-Economic Characteristics of Farmers on Their Adoption of Organic Farming Practices, Crop Production Technologies, Dr. Peeyush Sharma (Ed.), ISBN: 978-953-307-787-1.

Akudugu MA, Guo E, Dadzie SK (2012). Adoption of modern agricultural production technologies by farm households in Ghana: What factors influence their decisions? J. Biol. Agric. Healthcare 2(3):12- 20.

Alene AD, Manyong VM (2007). Gains from high-yielding varieties with and without complementary technologies: The case of improved cowpea in Northern Nigeria. J. Agric. Food Econ. 2(1):1-14.

Ango AK, Illo AI, Abdullahi AN, Maikasuwaand MA, Amina A (2013). Role of Farm-Radio Agricultural Programmes in Disseminating Agricultural Technology to Rural Famers for Agricultural Development in Zaria, Kaduna State, Nigeria. Asian J. Agric. Ext. Econ. Sociol. 2(1):54-68.

Arege A, Manyong VM, Gockowski J, Coulibaly O, Abele S (2006). A framework for conceptualising impact assessment and promoting impact culture in agricultural research. Int. Institute Trop. Agric. pp. 1-30.

Ayanwale A, Abdoulaye T, Ayedun B, Akinola A (2013). Baseline Report of the Sudan Savannah Zone of the Kano-Katsina-Maradi Pilot Learning Sites of The Sub Saharan Africa-Challenge Program (SSA CP) Baseline Report.

Ayayi MT, Solomon O (2010). Influence of extension contact and farmers socio-economic characteristics on adoption of oil palm technology in Aniocha North Local Government, Delta State- Nigeria.

Bamire SA, Abdoulaye T, Amaza P, Tegbaru A, Alene AD, Kamara AY (2010). Impact of promoting sustainable agriculture in Borno (PROSAB) progam on adoption of improved crop varieties in Borno State of Nigeria. J. Food Agric. Environ. 8(3):391-398.

Bello M, Daudu S, Galadima OE, Anzaku TKA, Abubakar AA (2012). Factors influencing adoption of crop-based technologies in Jenkwe Development Area of Nasarawa State, Nigeria. Glob. Adv. Res. J. Agric. Sci. 1(8):250-256.

Bonabana-Wabbi J (2002). Assessing factors affecting adoption of agricultural technologies: The case of Integrated pest management (IPM) in Kumi District, Eastern Uganda. Unpublished M.Sc Thesis, Virginia Polythenic Institute of State University.

Byerlee D, Heisey PW (1997). Evolution of the African maize economy. Chapter 2 in Africa's emerging maize revolution, edited by Byerlee D. and C. K. Eicher. Lynne Rienner Publishers, London, UK. pp. 46-48.

Ebojei CO, Ayinde TB, Akogwu GO (2012). Socio-Economic factors influencing the adoption oh hybrid maize in Giwa Local Government Area of Kaduna State, Nigeria. J. Agric. Sci. 7(1):23-32.

Ede DE (2011). Adoption of early maturing maize and cassava technology packages by farmers in Nkanu East and West of Enugu State, Nigeria. Unpublished M.Sc. Thesis submitted to the School of Postgraduate Studies, Ahmadu Bello University, Zaria-Nigeria.

Ellis-Jones J (2009). Kano-Katsina-Maradi Pilot Learning Site Sudan Savanna Agro- Ecological Zone Innovation Platform Creation. Sub Saharan Challenge Programme for Integrated Agricultural Research for Development. Draft Report, November 2009.

Gama EN (2013). Analysis of Productivity and Economic Efficiency of Cocoa Farmers in the South West Region of Cameroon. Unpublished Ph.D Dissertation submitted to the School of Postgraduate Studies, Ahmadu Bello University, Zaria-Nigeria.

Idrisa YI (2009). Analysis of the determinant of soybean production technology adoption by farmers in southern Borno State. Unpublished Ph.D Dissertation submitted to the School of Postgraduate Studies, University of Maiduguri, Borno-Nigeria.

Jones KM (2005). Technology Adoption in West Africa: adoption and disadoption of soybean on the Togo-Benin border. Unpublished M.Sc Thesis, North Carolina State University.

Kamara AY, Ellis-Jones J, Ekeleme F, Omogui LO, Amaza P, Chicoye D, Dugje IY (2010). A participatory evaluation of improved cowpea cultivars in the guinea Savanna zones of North East Nigeria. Taylor and Francis (pub). London W1T3JH, UK. Arch. Agron. Soil Sci. 56:3.

Kamara SM (2009). Factors influencing the adoption of Soybean Production among male and female farmers in Borno State: Implications for Community Development. Unpublished M.Ed. Thesis, Kano, Bayero University, Kano, Nigeria.

Kudi TM, Bolaji M, Akintola M, Nasa'I DH (2011). Analysis of adoption of early maturing maize varieties among farmers in Kwara State, Nigeria. Int. J. Peace Dev. Stud. 1(3):8-12.

Mbavai JJ (2013). An assessment of the effectiveness of the Sudan Savanna Taskforce project in adoption and diffusion of improved cowpea varieties in selected communities in Musawa Local Government Area of Katsina State. An M.Ed unpublished thesis submitted to the Department of Adult Education and Community Services, Faculty of Education, Bayero University Kano.

Mignouna BD, Abdoulaye T, Kamara A, Oluoch M (2013). Baseline study of smallholder farmers in *Striga*-infested maize and cowpea-growing areas of northern Nigeria. International Institute for Tropical Agriculture, Ibadan, Nigeria 60 pp.

Muyanga M (2009). Smallholder adoption and economic impacts of tissue culture banana in Kenya. Afr. J. Biotechnol. 8(23):6548-6555.

National Population Census (NPC) (2006). National Bureau of Statistics, Federal Republic of Nigeria. www.nigerianstat.gov.ng

Oboh VU, Aye GC, Hyande A (2006). Socio-economic Determinats of Farmers' Adoption of Improved Cassava varieties in Oju Local Government Area of Benue state. Proceedings of 20th Annual National conference of Farm Management Association of Nigeria. pp. 478- 482.

Onyibe JE, Kamara AY, Omoigui LO (2006). Guide to maize production in Borno State Nigeria. Published by IITA press Nigeria.

Reynolds MP, Pietragalla J, Braun HJ (2008). International Symposium on Wheat Yield Potential: Challenges to International Wheat Breeding. Mexico, D.F.: CIMMYT.

Smith J, Weber J, Mangong MV, Fakorede MAB (1997). Fostering sustainable increases in maize productivity in Nigeria. Chapter 8 in Africa's emerging maize revolution, edited by Byerlee D. and C. K. Eicher. Lynne Rienner Publishers, London, UK pp. 107-115.

Tambo AJ, Abdoulaye T (2011). Climate Change and Agricultural Technology Adoption: The Case of Drought Tolerant Maize in rural Nigeria. Springer Science + Business Media B.V. 2011.

Tarawali G, Kureh I (2004). Promoting sustainable agriculture in Borno State, a synthesis of livelihood analysis in three contrasting agro-ecological zones. Borno State. Nigeria: PROSAB pp. 1-45.

Yanguba A (2004). Agricultural technology adoption by small-scale farmers: The case of extra-early maize varieties in the Sudan savannas of Katsina State, Northern Nigeria. Unpublished M.Sc.

Thesis: University of Ibadan, Nigeria.
Zavale H, Mabaya E, Christy R (2005). Adoption of early maturing maize seed by smallholders' farmers in Mozambique. Staff Paper. SP 2005–03. Department of Applied Economics and Management, Cornell University, Ithaca, New York.

academicJournals

Vol. 7(8), pp. 282-291, August, 2015
DOI: 10.5897/JDAE2015.0652
Article Number: 2EDA2F754352
ISSN 2006-9774

http://www.academicjournals.org/JDAE

Journal of Development and Agricultural Economics

Full Length Research Paper

Technical, allocative, and economic efficiency among smallholder maize farmers in Southwestern Ethiopia: Parametric approach

Sisay Debebe[1]*, Jema Haji[1], Degye Goshu[1] and Abdi-Khalil Edriss[2]

[1]School of Agricultural Economics and Agribusiness, Haramaya University, P. O. Box: 05, Haramaya University, Ethiopia.
[2]Lilongwe University of Agriculture and Natural Resource, Bunda Campus, P. O. Box: 219, Lilongwe, Malawi.

Received 30 March, 2015; Accepted 6 June, 2015

Maize is one of the major five staple cereal crops in Ethiopia. High productivity and efficacy in its production is critical to improve food security, reduce the level of poverty and achieve or maintain agricultural growth. A multi-stage sampling technique was used to select 385 household heads and interviewed using a structured questionnaire during 2013/2014 production year. The study estimates, technical, allocative and economic efficiency using a parametric stochastic frontier production function (Cobb-Douglas). Inefficiency effects are modeled in a second stage applying a two-limit Tobit regression model. The results show that the mean technical, allocative and economic efficiency score was found to be 62.3, 57.1 and 39%, respectively, indicating a substantial level of inefficiency in maize production. The result depicted that important factors that affected technical, allocative and economic efficiency are a number of family size, level of education, extension service, cooperative membership, farm size, livestock holding and use of mobile. Based on the findings the following recommendations are forwarded. The government should motivate and mobilize the youth in agricultural activities, invest in the provision of basic education and facilitate the necessary materials, strengthen the existing agricultural extension system, organize non-member farmers in cooperative association and due attention should be given to enhance the efficiency of farmers with large land holding size. Further, government and stakeholders should promote the expansion of mobile networking in the study area.

Key words: Efficiencies, parametric stochastic approach, two-limit Tobit model, Ethiopia.

INTRODUCTION

The agriculture sector in Ethiopia plays pivotal roles in economic growth, poverty alleviation, employment creation, foreign exchange earnings and food security. Despite the enormous contribution over the past years, its significance is limited because of various factors and hence it is becoming increasingly difficult to meet the food requirements of the growing population (Jon, 2007; Abera, 2011; UNDP, 2013). One of the significant contributors for its deprived performance is the low productivity of the sector in general and cereal production

*Corresponding author. E-mail: sisaydebebe2000@gmail.com

in particular over the past years (Alemayehu, 2009; Alemayehu et al., 2012). Such low productivity leads to increasing poverty and food insecurity of rural poor farm households in the country.

During the past years, the government and NGOs have undertaken various attempts to enhance agricultural productivity particularly that of cereal crops so as to achieve food security and to reduce poverty in the country. The available studies on the productivity of cereal crops in general and maize production in particular in Ethiopia found low productivity in comparison with the international standards (Alemayehu, 2009), although, the current average national maize productivity of Ethiopia (32.54 quintal per ha) is better than the national productivity of many African countries. However, it is still low compared to that of the world average maize productivity (50 quintal per ha) (CSA, 2014; MoA, 2014). Besides, spatial variability in maize productivity is another concern for maize productivity enhancement in Ethiopia. For instance, in 2013/14, average maize productivity in Oromiya region varied from 40.03 quintal per ha (East Welega zone) to 24.06 quintal per ha (East Harerge zone). In the same year, the average maize productivity ranged from 39.42 quintal per ha (West Gojam zone) to 14.45 quintal per ha (Waghemra zone) in Amhara region. It also ranged from 39.45 quintal per ha (Silitie zone) to 18.91 quintal per ha (Bench-Maji zone) in the Southern Nations Nationalities and People's Region (SNNPR). Similarly, the average maize productivity varied from place to place in other regions too (CSA, 2014). Thus, raising production levels and reducing its variability are both essential aspects to improve food security and well-being of the people of Ethiopia.

According to previous research, a number of factors explain the low productivity and variability of maize in Ethiopia. Among others the existence of production inefficiency at farm level, lack of and inexistence of improved production technologies are the main factors that affect productivity of maize (Arega, 2003; Arega and Rashid, 2005; Jon, 2007). There are also different risk factors, which adversely affect maize yield. Weather risk and market risks are the major challenges for farmers. In addition to the above mentioned factors, low level of crop management practices, weeds, pest and diseases, erratic rainfall, erosion, low soil fertility, poor infrastructure, and post harvest crop losses are also growing concerns for the low productivity of maize crop in Ethiopia (ECEA, 2009).

On the other hand, the spatial variability of productivity of maize production could be due to several factors such as fluctuations in areas sown, fluctuations in weather conditions, changes in pricing and marketing policies, differences in the soil fertility status, availability of moisture during the growing season, and utilization of the recommended maize production and protection technologies (Zerihun, 2003; Anderson and Kay, 2010). Thus, the existence of such constraints significantly affects farmers' efforts of improving productivity, enhancing their food self-sufficiency and increasing their family income.

Previous studies conducted in the area of maize production efficiency, except that of Arega (2003), Arega and Rashid (2005), Aye and Mungatana (2010) deals exclusively with technical efficiency of farmers and the factors considered to be important in determining the efficiency of maize farming (Wambui, 2005; Ephraim, 2007; Elibariki et al., 2008; Endrias et al., 2010), Although the analysis of technical efficiency of maize farming is important, there is limited empirical research done so far in Ethiopia particularly on the estimation of other efficiencies (allocative and economic) of maize farming in the country. Understanding the levels of these efficiencies and their determinants contribute a lot to the identification of production constraints at farm level and thereby improve the food security and income sources in the farm sector and the rest of the economy. Furthermore, such knowledge may help policy-makers to design appropriate policies to increase agricultural productivity through improving on farm-and crop specific efficiencies. This research aims to take a step towards filling the above noticeable gaps of knowledge by collecting cross-sectional data from maize-dominated smallholder farmers of southwestern Ethiopia.

METHODOLOGY

Study area

The study was carried out in the Jimma zone of Oromia regional state in southwestern Ethiopia. Jimma zone is located southwestern parts of Addis Ababa and it is one of the major maize growing areas of Ethiopia. Based on the 2008 census report of CSA the zone has a total population of 2,495,795 of whom 1,255,130 are men and 1,240,665 women. Jimma zone bordered with east Wollega zone in the north, with east shawa zone and southwest Shawa zone in the northeast, with SNNPR administration in the southeast and south part, and with Illubabor zone in the west. Jimma zone divided into 17 *woredas* (districts) and it lies between latitudes 7°15´ N and 8°45´ S, and longitudes 36° 00´ E and 37°40´ E (BoFED, 2008). Jimma zone generally lies with the altitude ranges between 900 and 3334 m above sea level. More than half of the zone (52%) lies between 1500 and 2000 m above sea level. Areas between 1500 and 2000 m above sea level are found in the all areas of *Limmu*-Seka, Menna, east Kersa, northern area of Dedo, Omonada, eastern and southern Gera, Seka-Chekorsa and Sokoru and eastern Gomma. On the other hand, the majority of the remaining *woredas* has an intermediate plateau topography that highly ideal for farming, which lies within altitude 2000 to 2500 m (Socio-Economic Profile Report, 2009).

Sampling techniques and the data

The study was based on cross-sectional data that were obtained through a farm household survey administered on 385 randomly selected smallholder farmers drawn by multi-stage sampling techniques in 2013/14 production season. The three-stages that involve the selection of (1) *woredas (district)*, (2) *kebeles* (lower administrative unit) and (3) smallholder farmers are as follows: In the first stage, three *woreda,* namely Omonada, Seka-Chekorsa and Kersa were randomly selected from 12 maize growing *woredas* of Jimma zone of southwestern Ethiopia. In the second stage, the study included 15% of total maize growing *Kebeles* within each of the three selected *woredas* using simple random sampling method. Based on these criteria, four *kebeles* from Omonada and two *kebeles* from Seka-Chekorsa and three *kebeles* from Kersa *woreda* were selected randomly that give rise to a total of nine *Kebeles*. In the third stage, the study selected 385 smallholder farmers randomly from lists of names of maize farmers in the *kebeles* using a computer-generated random number table. The data set contains detailed information on households' demographic and socioeconomic characteristics, farm specific attributes, marketing, and institutional characteristics.

Analytical methods

The analysis of efficiency was carried out following the Aigner et al. (1977) method of the estimating the Stochastic Frontier Production Functions (SFPF). The study specified the SFPF using a Cobb-Douglas production function for smallholder maize producing farmers in the Jimma zone of southwestern Ethiopia as:

$$LogY_i = \beta_0 + \sum_{J=1}^{4} \beta_j LogX_{ji} + (v_i - u_i) \quad (1)$$

Where Y is the total quantity of maize cultivated (in kilogram); X_1 represents the plot size under maize cultivation (hectares) on the i^{th} farm; X_2 represents family and hired labor used for maize production (man-days) on the i^{th} farm; X_3 denotes the amount of fertilizer in kilogram applied to land for maize production of the i^{th} farm; X_4 denotes the amount of other inputs such as seed in kilogram, pesticide and herbicide in liters applied to land for maize production of the i^{th} farm; β_j j = 0, 1,..., 4 are parameters to be estimated; V_i are assumed to be independent and identically distributed N (0, σ^2) random variables; μ_i s are assumed to be independent and identically distributed non-negative truncations of the N(u, δ^2) distribution.

The second stage of analysis is to explain Technical Efficiency (TE) of maize farming. TE is the ability of a farmer to obtain maximum (optimal) output from a given set of inputs and technology. Using the above estimated Cobb-Douglas production function in Equation (1), estimation of TE for individual farms is predicted by obtaining the ratio of the observed production values to the corresponding estimated frontier values. The value achieves its maximum feasible value if and only if TE_i =1 otherwise, TE_i<1. The TE for the i^{th} farms can be computed as:

$$TE_i = \left[\frac{\log Y_i = \beta_0 + \sum_{J=1}^{4} \beta_j LogX_{ji} + (v_i - u_i)}{\log Y_i = \beta_0 + \sum_{J=1}^{4} \beta_j LogX_{ji} + v_i} \right] \quad (2)$$

Following Bravo-Ureta and Rieger (1991) Efficiency Decomposition Techniques (EDT), the study computed the dual cost frontier in Equation (3) based on the estimated production frontier in Equation (2) and this forms the basis of computing the EE and AE of maize production. The dual cost frontier was computed as:

$$\ln C_i = \phi_0 + \phi_1 \ln C_{land} + \phi_2 \ln C_{labour} + \phi_3 \ln C_{Fertilzer} + \phi_4 \ln C_{Others} + \delta \ln Y_i + \mu_i \quad (3)$$

Where C is the cost of maize production for the i^{th} farmer, C_{Land} is the total rental price of land per hectare estimated at market price. C_{Labor} the total price of labor per day estimated at market price, $C_{Fertilizer}$ is the total price of fertilizer per kg estimated at market price, and C_{others} are the total price of seed per kg, pesticide and herbicides per liter estimated at market. The maximum likelihood estimates of the parameters of the parametric approach of stochastic frontier estimation for both SFPF and EDT were estimated using the STATA version 12.

To analyze the effect of demographic, socioeconomic, farm attributes, marketing, institutional variables on efficiencies, a second stage procedure was used where the efficiency scores regressed on selected explanatory variables using two-limit Tobit model. This model is best suited for such analysis because of the nature of the dependent variable (efficiency scores), which takes values between 0 and 1 and yield the consistent estimates for unknown parameter vector (Maddala, 1999).

Following Maddala (1999) the model can be specified as:

$$Y_j^* = \beta' X_{jk} + \mu_i \quad (4)$$

Denoting Y_j as the observed dependent (censored) variable:

$$y_i = \begin{cases} L & if \ Y_j^* \leq L \\ Y_j^* & if \ 0 \ L < Y^* < U \\ U & if \ Y_i^* \geq U \end{cases} \quad (5)$$

Where y_i is the observed dependent variables, in our case efficiency of maize production of farm j (unobserved for values smaller than 0 and greater than 1), X_{jk} is a vector of explanatory variable k (l = 1, 2, …..,k) for farm k and μ_i an error term that is independently and normally distributed with mean zero and variance σ^2 and is independent of X_{jk}. The distribution of the dependent variable in the equation (5) is not a normal distribution because its value varies between 0 and 1.

Following Maddala (1999), the likelihood function of this model is specified as:

$$L(\beta, \delta | y_j, X_j L_{1j}, L_{2j}) = \prod_{y_j - L_{1j}} \varphi\left(\frac{L_{1j} - \beta' X_j}{\delta}\right) \prod_{y_j = y_j^*} \varphi\left(\frac{y_j - \beta' X_j}{\delta}\right) \prod_{y_j - L_{2j}} \varphi\left(\frac{L_{2j} - \beta' X_j}{\delta}\right) \quad (6)$$

Where L_{1j} = 0 (lower limit) and L_{2j} = 1 (upper limit) were and are normal and standard density functions.

In a two-limit Tobit model, each marginal effect includes both the influence of explanatory variables on the probability of the dependent variable to fall in the uncensored part of the distribution and on the expected value of the dependent variable conditional on it being larger than the lower bound. Thus, the total marginal effect takes into account that a change in explanatory variable will have a simultaneous effect on the probability of being efficient in maize production and value of efficiency scores in maize production.

McDonald and Moffitt (1980) proposed useful decomposition techniques of total marginal effects and later developed by Gould et al. (1989). Based on the likelihood function of the model stated in equation (6), the total marginal effect divided into the three marginal effects as follows:

1. The unconditional expected value of the dependent variable:

Table 1. Descriptive statistics of variables and their expected hypothesis.

Notation	Variable description	Mean (S.D)	Measurement	Expected sign
	Demographic characteristics			
FEMALE	Female household head	11.4 (0.32)	Dummy	**-**
AGE	Age of household head	45.35 (8.85)	Years	**+**
FAMSIZE	Total family size	5.5 (2.05)	Number	**+**
	Socio-economic characteristics			
EDUFAR	Number of years of formal education	2.78 (1.66)	Years	**+**
TLU	Total number of livestock size	4.71 (2.52)	TLU	**+**
	Farm attributes			
EXPMFAR	Experience of farmer in maize production	22.67 (9.21)	Years	**+**
FARMSIZE	Total farm size	1.63 (0.67)	Hectare	**+/-**
	Institutional service			
FREEXT	Frequency of extension contact	3.32 (3.3)	Number	+
DSTCD	Distance to development center	0.86 (0.79)	Walking hour	-
COOP	Membership of farmer cooperative	45.97 (0.50)	Dummy	**+**
CREDIT	Use of cash credit for maize	16.36 (0.37)	Dummy	**+**
	Marketing access			
MOBILE	Use of mobile cell phone	71.14 (0.45)	Dummy	+
DSTMKT	Distance of to market center	2.31 (1.42)	Walking hour	-

Source: Computed from survey data

$$\frac{\partial E(y^*)}{\partial x_j} = [\varphi(Z_U) - \varphi(Z_L)]\frac{\partial E(y^*)}{\partial x_j} + \frac{\partial[\varphi(Z_U) - \varphi(Z_L)]}{\partial x_j} + \frac{\partial(1-\varphi(Z_U)}{\partial x_j} \quad (7)$$

2. The expected value of the dependent variable conditional upon being between the limits:

$$\frac{\partial E(y^*)}{\partial x_j} = \beta_k\left[1 + \frac{\{Z_L\varphi(Z_L) - Z_U\varphi(Z_U)\}}{\{\varphi(Z_U) - \varphi(Z_L)\}}\right] - \left[\frac{\{\phi(Z_L) - \phi(Z_U)\}^2}{\{\varphi(Z_U) - \varphi(Z_L)\}^2}\right] \quad (8)$$

3. The probability of being between the limits:

$$\frac{\partial[\varphi(Z_U - \varphi(Z_L]}{\partial x_j} = \frac{\beta_k}{\delta}.[\phi(Z_L) - \phi(Z_U)] \quad (9)$$

Where $\varphi(.)$ is the cumulative normal distribution, $\phi(.)$ is the normal density function, $Z_L = -\beta' X / \delta$ and $Z_U = (1-\beta X)/\delta$ are standardized variables that came from the likelihood function given the limits of y*, and δ is the standard deviation of the model.

Definition of variables, measurement and hypotheses

Adoption literature provides a number of factors influencing the level of efficiency of maize production. Generally, the level of efficiency are hypothesized to be influenced by a combined effect of various factors such as demographic, socioeconomic, farm attributes, marketing and institutional characteristics. Summary statistics of the variables used in the two-limit Tobit model provided in Table 1.

RESULTS AND DISCUSSION

The maximum likelihood (ML) estimates of the parameter of the stochastic frontier Cobb-Douglas production function results are presented in Table 2. The standard ordinary least squares (OLS) estimate is also presented for comparison. The results show that all coefficient estimates are significant at one percent level of significance and have expected signs thereby determining maize production in the Jimma zone of southwestern Ethiopia. The ratio of the standard error of $\mu(\delta_\mu)$ to the standard error of $\nu(\delta_\nu)$, known as lambda (λ) is 3.1, which measures the effect of technical inefficiency in the variation of observed output, $\gamma = \lambda^2/[1+\lambda^2] = \delta_\mu^2/\delta_\varepsilon^2$. The estimated value of (γ) is 0.48, which is an estimate of the variance parameter and significant at 1% level of significance implying that 48% of the total variation in output is due to existence of production inefficiency. This result is confirmed by conducting a likelihood ratio test to compare OLS model versus frontier model in representing the surveyed data. Likelihood ratio test statistic provided a statistic of 11.61 distributed with chi-square four degrees of freedom, which is significant at one percent level of significance, thus rejecting the adequacy of the OLS model in representing the data.

The cost frontier dual to the Cobb-Douglas production

Table 2. The ML and OLS estimates of the parametric stochastic production frontier.

Variable	Parameter	ML estimates Coefficient (Std. Err.)	OLS estimates Coefficient (Std. Err.)
Intercept	δ	2.06 *** (0.325)	1.05 *** (0.325)
Ln (Land)	β_1	0.46 *** (0.874)	0.45 *** (0.099)
Ln (Labor)	β_2	0.140 *** (0.041)	0.173 *** (0.053)
Ln (Fertilizer)	β_3	0.088 *** (0.017)	0.10 *** (0.016)
Ln (Others)	β_4	0.16 *** (0.063)	0.24 *** (0.069)
Variance parameters:			
Sigma-Squared	$\delta^2 = \delta_u^2 + \delta_v^2$	3.1*** (0.10)	
Gamma	$\gamma = \delta_u^2 / \delta^2$	0.48*** (0.07)	
Log-likelihood		-225.14	

Source: Model result.

frontier shown in Table 3 is analytically derived and this formed the basis of computing the AE (allocative efficiency) and EE (economic efficiency). The dual cost frontier is given as:

$$LnC_i = 1.95 + 0.38 lnC_{land} + 0.21 lnC_{labour} + 0.06 LnC_{Fertilizer} + 0.26 C_{othres} + 0.05 lnY_{PRODi}$$

Where C_i is the cost of maize production for the i^{th} farmer, Y_{PRODi} is total maize output in kg of the i^{th} farm, C_{Land} is the rental price of land per hectare estimated at Birr 3,500, C_{Labour} is the price of labor per day estimated at Birr 20, $C_{Fertilizer}$ is the price of chemical fertilizer per kg estimated at Birr 29.21 and C_{Others} is a price index of seed estimated at Birr 17.44 per kg of seed and price of pesticide and herbicide estimated at 550 Birr per liter.

The study found out that the average technical efficiency of the sample farms is 0.623, with a minimum level of 0.211 and the maximum level of 0.943. This means that if the average farmer in the sample was to achieve the technical efficient level of its most efficient counterpart, then the average farmer could realize a 34% increase in output by improving technical efficiency with existing technology. The mean allocative efficiency of the sample farms is estimated at 0.571, with a low of 0.183 and a high of 0.887. A similar calculation for the allocative efficiency farmer reveals 36% increase in output by improving allocative efficiency, with existing technology. The combined effect of technical and allocative factors shows that the average economic efficiency level is only 0.39, with a low of 0.041 and a high of 0.837. This result indicates that if the average farmer in the sample were to reach the economic efficiency level of his/her most efficient counterpart, then the average farmer could experience a 53% increase in output by improving both economic and allocative efficiency, with the existing technology. Therefore, this result shows the existence of significant technical, allocative and economic inefficiency in maize production among maize producing smallholder farmers in the study area.

The mean levels of efficiencies were comparable to those from other similar studies in Ethiopia. For example, Seyoum et al. (1998) find the mean technical efficiency of maize producers in Eastern Ethiopia for farmers within and outside the Sasakawa-Global 2000 project to be 88 and 74%, respectively. Arega and Rashid (2005) found mean technical, allocative and economic efficiencies of 68, 83 and 56% respectively for traditional maize producers and 78, 77 and 61% respectively for hybrid maize producing farmers in Eastern Ethiopia. However, Endrias et al. (2010) found low average technical efficiencies of 40% among maize producing farmers in Southern Ethiopia using DEA and normalized Translog production function.

After measuring the level of TE, AE and EE index, it was necessary to identify which demographic, socio-economic, farm attributes, marketing, institutional factors influencing the level of TE, AE and EE in maize production. To identify factors influencing efficiencies, a “second step” estimation techniques of Bravo-Ureta and Rieger (1991) followed, the following two-limit Tobit model estimated in Table 3. Before explaining the model, a test on multi-collinearity and hetroscedasticity were made. The VIF was found to be low (a maximum VIF of 1.62). This shows that there is no problem of multi-collinearity in the data set. The Breusch-Pagan test for hetroscedasticity indicated a small chi-square (0.91 for TE and 0.94 for AE and 1.92 for EE), implying there was

Table 3. Tobit results on technical, allocative and economic efficiency of maize production.

Variables	Technical efficiency		Allocative efficiency		Economic efficiency	
	Coefficient (Std. Error)	Marginal effects	Coefficient (Std. Error)	Marginal effects	Coefficient (Std. Error)	Marginal effects
FAMSIZE	0.02 ***	0.0200	0.02 ***	0.0189	0.02 ***	0.0223
	(0.005)	0.0189	(0.004)	0.0185	(0.005)	0.0207
		0.0032		0.0008		0.0050
EDUFAR	0.01 **	0.0108	0.01 *	0.0098	0.01 **	0.0114
	(0.005)	0.0102	(0.005)	0.0096	(0.006)	0.0105
		0.0017		0.0004		0.0044
TLU	0.02 ***	0.0204	0.02 **	0.0211	0.02 ***	0.0221
	(0.004)	0.0193	(0.004)	0.0207	(0.0040)	0.0205
		0.0033		0.0207		0.0044
FARMSIZE	-0.04 ***	-0.0439	-0.04 ***	-0.0442	-0.06 ***	-0.0006
	(0.013)	-0.0415	(0.013)	-0.0433	(0.014)	-0.0568
		-0.0071		-0.0020		-0.0001
FREEXT	0.01 ***	0.0140	0.01 ***	0.0127	0.02 ***	0.0155
	(0.003)	0.0133	(0.003)	0.0125	(0.003)	0.0144
		0.0023		0.0006		0.0031
COOP	0.04 **	0.0360	0.03 **	0.0320	0.04 **	0.0437
	(0.018)	0.0340	(0.017)	0.0314	(0.020)	0.0106
		0.0060		0.0049		0.0085
MOBILE	0.06 ****	0.0603	0.05 **	0.0240	0.06 ***	0.0635
	(0.020)	0.0575	(0.020)	0.0457	(0.224)	0.0017
		0.0002		0.0002		0.0153
CONS	0.32***		0.31 ***		0.07	
	(0.059)		(0.055)		(0.064)	

***, ** and * indicate the level of significance at 1, 5 and 10%, respectively; Marginal effects computed only for significant variables and value in cell explain $\frac{\partial E(y)}{\partial X_j}$ (Total change), $\frac{\partial E(y^*)}{\partial X_j}$ (Expected change) and $\frac{\partial[\varphi(Z_U)-\varphi(Z_L)]}{\partial X_j}$ (Change in probability). Source: Model results.

no hetroscedasticity problem in the data. In addition, a test for normality of TE, AE and EE were also made using Kernel density estimate and Jargue-Bera test. Kernel density estimate graph resembles the normally distributed curve (Figure 1). Jarque-Bera test also indicated a higher chi-square for 25.11 (TE), 21.11 (AE) and 21.98 (EE), implying TE, AE and EE is normality distributed.

The parameter estimates of the model are presented in Table 3. According to the result of the model, technical, allocative and economic efficiency of maize production are positively and significantly influenced by the size of household (FAMSIZE), education level of household head (EDUFAR), the size of livestock holding (TLU), extension service (frequency of contacts) (FREEXT), cooperative membership (COOP) and use of mobile cell-phone (MOBILE) whereas, negatively and significantly influencing total landholding size of the household head (FARMSIZE).

The number of family size in the household has a positive and highly significant impact on TE, AE and EE at one percent level of significance. A possible reason for this result might be that a larger household size guarantees availability of family labor for farm operations to be accomplished in time. At the time of peak seasons, there is a shortage of labor and hence household with large family size would deploy more labor to undertake the necessary farming activities like ploughing, weeding and harvesting on time than their counterparts and hence they are efficient in maize production. Moreover, the computed marginal effect of household size showed that a one person change in the number of household size would increase the probability of farmer to fall under TE, AE and EE category by 0.32, 0.08 and 0.5% and the

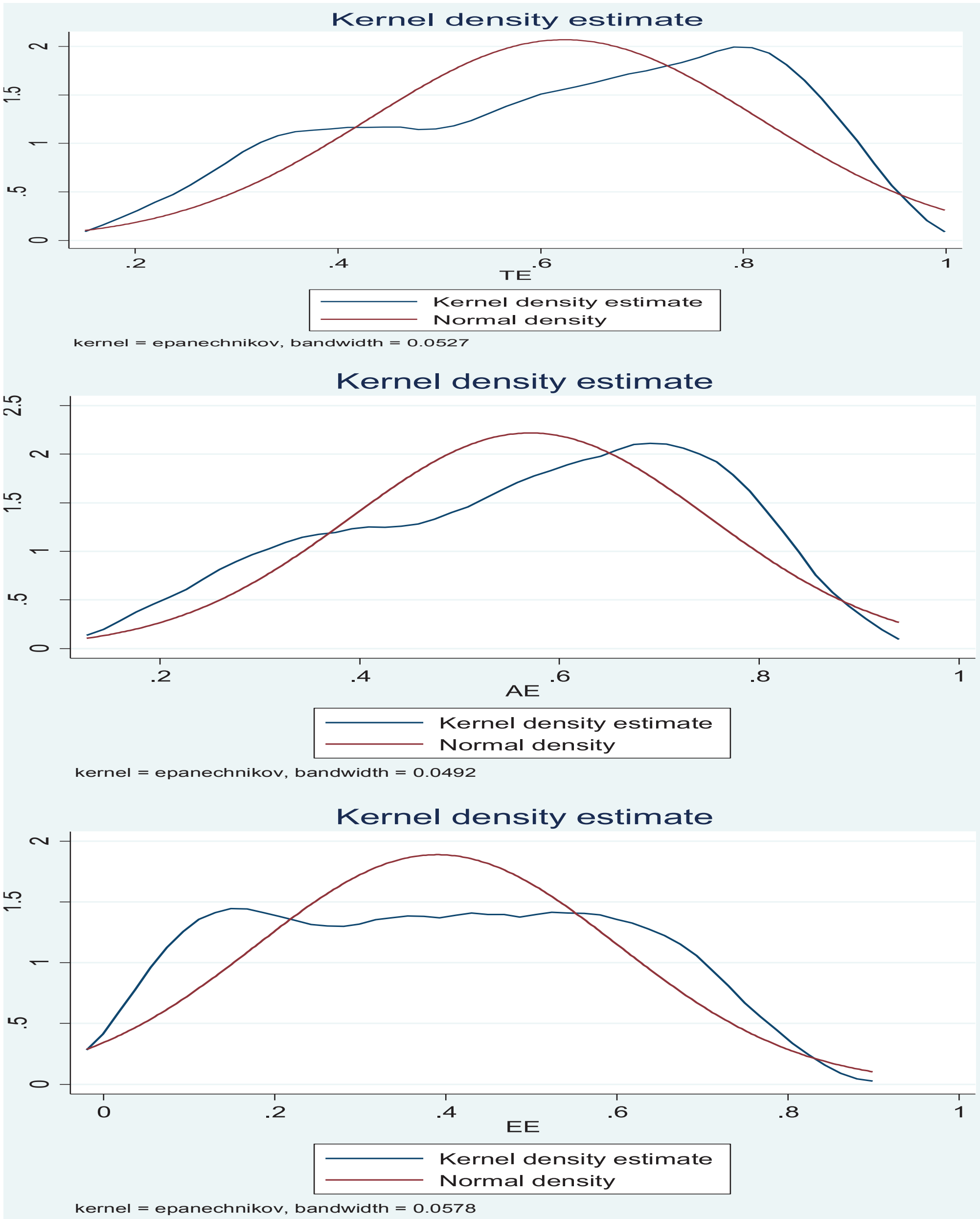

Figure 1. Kernel density estimate for efficiencies. Source: Computed from survey data.

expected value of TE, AE and EE by 0.19, 0.19 and 0.21% with an overall increase in the probability and the level of efficiencies by 0.20 0.19 and 0.22%, respectively. Similar positive and significant impact of household size on efficiency was found by Elibariki et al. (2008), Aye and Mungatana (2010) and Shumet (2011) in their respective studies.

As expected, education of the household head has a positive and significant effect on TE, AE and EE of maize production at five and ten percent level of significance, suggesting that better-educated household head can understand agricultural instructions easily, have higher tendency to adopt improved production technologies, have better access to information, and be able to apply technical skills imparted to them than uneducated ones. Thus, the level of education of household head emerges as an important factor in enhancing efficiencies of maize production in the study areas. Moreover, a one year increase in educational attainment level of the household head increases the probability of a farmer to fall under TE, AE and EE category by 0.17 0.04 and 0.44% and change in the expected value of TE, AE and EE by about 0.10, 0.96 and 0.11% with an overall increase in the probability and levels of efficiencies by 0.11, 0.98 and 0.11%, respectively. This result is consonant with other similar studies such as Arega and Reshid (2005), Elibariki et al. (2008), Aye and Mungatana (2010), Otitoju and Arene (2010), Shehu et al. (2010) and Shumet (2011) who found that a farmer with greater year of schooling tends to be higher efficient in crop production.

The amount of livestock owned, which is a proxy for estimating wealth status of a farmer, has a positive and significant effect on TE, AE and EE in maize production at one percent level of significance. Farmers who owned a few number of livestock's were technically, allocativelly and economically more efficient than those who owned less number of livestock's in the production of maize. This is because livestock provides a working power (oxen for draught power), manure fertilizer and is a source of income that can be used to purchase the necessary agricultural inputs. Thus, possessing a large number of livestock's is crucial to increase TE, AE and EE in maize production in the study areas. Each unit increase in the value of TLU would increase the probability of a farmer to fall under TE, AE and EE category by 0.33, 0.21 and 0.44% and the expected value of TE, AE and EE by about 0.19, 0.21 and 0.21% with an overall increase in the probability and the level of efficiencies by 0.20, 0.21 and 0.22%, respectively. These results are consistent with the findings of Beyene (2004), Amos et al. (2007), Idiong et al. (2009), Otitoju and Arene (2010) and Shehu et al. (2010) in their respective studies.

A negative and statistically significant relationship between land holding size and TE, AE and EE at one percent level of significance supports the notion that small-size farms have an efficiency advantage of efficiency over the other farms in the sample. The link between efficiency and land holding size has been the subject of much discussion in the literature. Various studies have found a small landholding size to have a positive impact on crop level efficiency because of its simplicity in management and less transaction cost compared to the large farm size (Amos et al., 2007; Elibariki et al., 2008; Idiong et al., 2009; Otitoju and Arene, 2010). On the other hand, several other researchers have found a negative and statistically significant relationship between these two variables because large land holding farmers are more likely to employ modern agricultural practices and hence could be more efficient due to its advantage of the economic scale and scope associated with large farm size (Beyene, 2004; Hussein, 2007; Endrias et al., 2010). Thus, this study contributes to the ongoing debate on the relationship between farm size and efficiency by providing more results showing land holding size has a negative and significant effect on the efficiencies of maize production. Moreover, a unit change in farm size would result in 0.71, 0.20 and 0.01% change in the probability of a farmer being technically, allocativelly and economically efficient and the expected value of TE, AE and EE by 0.42, 0.43 and 0.57% with an overall increase in the probability and the level of efficiency by 0.44, 0.44 and 0.06%, respectively.

The relationship between extension service (frequency of extension contacts) and TE, AE and EE in maize production has a positive and statistically significant effect at one percent level of significance. That is, farmers who had more number of extension contact during the cropping period were technically, allocativelly and economically more efficient than those who had less number of extension contact during the cropping period. Thus, frequency of extension contacts with development agents is crucial to increase TE, AE and EE of maize production in the study areas. Each increase in the frequency of extension contact would increase the probability of a farmer to fall under TE, AE and EE category by 0.23, 0.06 and 0.31% and the expected value of TE, AE and EE by about 0.13, 0.13 and 0.14% with an overall increase in the probability and the level of efficiencies by 0.14, 0.13 and 0.16%, respectively. The results of studies by Arega and Reshid (2005), Fasorant (2006), Hussein (2007), Aye and Mungatana (2010), Otitoju and Arene (2010) and Shehu et al. (2010) who found that extension agents provide farmers with new information on improved production technologies, recommended agronomic practices, market and etc. Farmers who had more number of contacts with such agents improved their access to improved inputs and farming management practices thereby increased their production efficiencies.

The results concerning membership of the household head to farmer cooperatives has a positive and statistically significant effect on TE, AE, and EE at five percent level of significance. Farmer membership to farmer cooperatives is used as a proxy for measuring the role of social organization in the production process. Farmers who are members of farmer cooperatives received viable information on production technologies than farmers who are not members of the cooperatives. As a result, they experiment and apply new production technologies and hence they are more efficient in maize production. Moreover, a change in the dummy variable representing the membership of farmer cooperatives by the household head ordered from 0 to 1 would increase the probability of the farmers to fall under TE, AE and EE category by about 0.60, 0.49 and 0.85% and change the expected value of TE, AE and EE by about 3.4, 3.1 and 1.1% with an overall increase in the probability and the level of efficiencies by 3.6, 3.2 and 4.4%, respectively. Similarly, Benin et al. (2004), Fasorant (2006), Ephraim (2007) and Shehu et al. (2010) also arrived at the same result using the club membership to capture the role of social organization in providing incentives for efficient crop production.

Finally, the coefficient of the dummy variable for use of mobile cell phone for accessing marketing information has a positive and statistically significant effect on both TE and EE at one percent levels of significance. The association with AE is also positive and significant at five percent level of significance. The result implies that a farmer who owns a mobile cell phone has a better market information access and hence more likely to be efficient in maize production than those farmers who did not own mobile cell phone. Moreover, a change in the dummy variable representing the use of mobile cell phone order from 0 to 1 would increase the probability of the farmers to fall under TE, AE and EE category by about 0.02, 0.02 and 0.15% and change the expected value of TE, AE and EE by about 5.8, 4.6 and 0.17% with an overall increase in the probability and levels of efficiencies by 0.6, 2.4 and 6.4%, respectively.

CONCLUSION AND POLICY IMPLICATION

The study found the existence of substantial technical, allocative and economic inefficiency in maize production in the study area. The average technical, allocative and economic efficiency levels have estimated at 62.3, 57.1 and 39%, respectively. This implied an average of 53% growth of maize production through full technical and economic efficiency improvement, which indicates a considerable potential for enhancing productivity of maize in the area. Therefore, the attention of policy makers to improve food security, reduce poverty and achieve or maintain agricultural growth by raising the productivity of smallholder agriculture should not stick only on the use of improved production technologies and best farm technologies, but they should also give due attention towards improving the existing level of the inefficiencies of maize producing farmers. These inefficiencies, however, can be improved if major factors that determine efficiencies are identified.

The positive significant and higher elasticity of production inputs indicates the importance of these inputs in maize production. This implies that enhanced access and better use of these production inputs could lead to higher maize production in the study area. The key policy implication therefore is that strengthening policies that motivate and mobilize the rural population in agricultural activities, providing easy and affordable credit service as the high cost of chemical fertilizer was the most frequently mentioned problems that hindered its use in the area would increase the use of chemical fertilizer inputs, and policies that can further increases land allotted for maize production can be taken as an alternative to enhance productivity. This may include the consolidation and efficient use of the existing fragmented farms and strengthening the resettlement programs in the area.

The positive contribution of size of household on TE, AE and EE of farm households' needs policy attention that would motivate and mobilize the rural population, particularly the youth, in agricultural activities. Education attainment level is an important factor in TE, AE and EE, the key policy implication is that appropriate policy should be designed to provide adequate and effective basic educational opportunities for farmers in the study area. In this regards, the regional government should have a prime responsibility to keep on providing basic education in these areas and facilitates the necessary materials so that farmers can understand agricultural instructions easily and have better access to product information and use the available inputs more efficiently. The size of livestock holding by household positively affected the TE, AE and EE of maize producing farmers, the study suggested strengthening the existing livestock production system through providing improved health service, better nutrition, targeted credit, and providing other necessary supports. Total farm size was a negatively affecting the TE, AE and EE, this provides an important lesson for other similar agro-ecology areas of small-size farm owners that better efficiency in maize production could be obtained with their limited land sizes. At the same time, the result suggests the regional agriculture offices should give due attention to large size farmers so as to enhance efficiencies in their production. Based on a positive contribution of extension service on TE, AE and EE, policies and strategies should therefore place more emphasis on strengthening the existing agricultural extension service through providing incentive, recruitment, training and upgrading the educational level of extension workers, and providing non-overlapping and congruent responsibilities of extension worker in the study area. Membership of household to farmer cooperatives plays a positive role in affecting the TE, AE and EE, this need strengthening the existing farmer cooperatives through providing incentives, awareness creation on its benefits should be taken as an important step towards organizing non-member farmers in the cooperatives. Finally, the use of mobile cell phone was positively related to TE and EE, improving the existing telecommunication service, particularly the expansion of mobile networking in the study areas should be given policy attention.

Conflict of Interest

The authors have not declared any conflict of interest.

REFERENCES

Aigner D, Lovell K, Schmidt P (1977). Formulation and estimation of stochastic frontier production function models. J. Econ. 6:21–37.

Alemayehu S, Dorosh P, Sinafikeh A (2012). Crop production in Ethiopia: Regional Patterns and Trends Ethiopia in Food and Agriculture in Ethiopia: Progress and Policy challenges edited by Dorosh, P. and Rashid, S. University of Pennsylvania: Philadelphia.

Alemayehu S (2009). Cereal Production in Ethiopia: Recent Trends and Sources of Growth: International Food Policy Research Institute, Mimeo. Addis Ababa, Ethiopia.

Amos T, Chikwendu D, Nmadu J (2007). Productivity, technical efficiency and cropping patterns in the Savanna Zone of Nigeria. J. Food Agric. Environ. 2:173-176.

Anderson L, Kay G (2010). Yield gap and productivity potential in Ethiopian Agriculture: Staple Grains and Pulses: Prepared for the

Farmer Productivity Team of the Bill and Melinda Gates Foundation. Brief No. 98, Evans School Policy Analysis and Research (EPAR), Washington University.
Arega D (2003). Improved Production Technology and Efficiency of Smallholder Farmers in Ethiopia: Extended parametric and non-parametric approaches to production efficiency analysis. Doctoral Dissertation. University of Pretoria, South Africa.
Arega D, Rashid M (2005). The efficiency of traditional and hybrid maize production in Eastern Ethiopia: An extended efficiency decomposition approach. J. Afr. Econ. 15(1):91-116.
Aye G, Mungatana D (2010). Technological Innovation and Efficiency in the Nigerian Maize Sector: Parametric Stochastic and Non-parametric Distance Function Approaches. Contributed Paper presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, September 19-23, 2010, Cape Town, South Africa.
Benin S, Smaleb M, Pender J, Berhanu G, Ehui MS (2004). The Economic Determinants of Cereal Crop Diversity on Farms in the Ethiopian Highlands. J. Agric. Econ. 31:197-208.
Beyene T (2004). The Impact of Policy Reform and Institutional Transformation on Agricultural Performance: An Economic Study of Ethiopian Agriculture. Development Economics and Policy. Doctoral Dissertation, University of Hohenheium, Germany.
BoFED (Bureau of Finance and Economic Development) (2008). Regional Atlas of Oromia. Addis Ababa, Ethiopia.
Bravo-Ureta BE, Rieger L (1991). Dairy Farm Efficiency Measurement Using Stochastic Frontiers and Neoclassical Duality. Am. J. Agric. Econ. 73:421-428.
CSA (Central Statistical Authority) (2008). A Summary and Statistical Report of the 2007 Population and Housing Census of Ethiopia: Population Size by Age and Sex. Federal Democratic Republic of Ethiopia Population Census Commission, Addis Ababa.
CSA (2014a). Agricultural Sample Survey 2013/2014 (2006 E.C.): Volume I – Report on Area and Production of Major Crops (Private Peasant Holdings, *Meher* Season). Statistical Bulletin. Addis Ababa: Central Statistical Agency.
Elibariki E, Shuji H, Tatsuhiko N (2008). An Analysis of Technical Efficiency of Smallholder Maize Farmers in Tanzania in the Globalization Era. Contributed paper and presented in the XII World Congress of Rural Sociology of the International Rural Sociology Association, Goyang, Korea.
Endrias G, Belay K, Ayalneh B, Eyasu E (2010). Productivity and Efficiency Analysis of Smallholder Maize Producers in Southern Ethiopia. J. Hum. Ecol. 41(1):67-75.
Ephraim W (2007). Sources of Technical Efficiency among Smallholder Maize Farmers in Southern Malawi. African Economic Research Consortium, research paper 172, Nairobi, Kenya.
Ethiopian Commodity Exchange Authority (ECEA) (2009). Understanding maize: A review of supply and marketing issues, Addis Ababa. Ethiopia.
Hussein H (2007). Farm Household Economic Behavior in Imperfect Financial Markets: Empirical Evidence and Policy implications on Saving, Credit and Production Efficiency in Southeastern Ethiopia, Doctorial Dissertation, Faculty of Natural Resource and Agricultural Sciences Department of Economics, Uppsala, Sweden.
Idiong I, Agom CD, Effiong EO, Ohen SB (2009). Analysis of Technical and Economic Efficiencies in Rice Production Systems in The Niger Delta Region of Nigeria. In Sustaining Agricultural Growth to Meet National Economic Development Goal. Proceedings of the 23rd Annual Conference of the Farm Management Association of Nigeria *(*FAMAN).
Jon P (2007). The Adoption and Productivity of Modern Agricultural Technologies in the Ethiopian Highlands: A Cross-Sectional Analysis of Maize Production in the West Gojam Zone, University of Sussex.
Maddala GS (1999). Limited dependent variable in econometrics. Cambridge University Press, New York.
McDonald JF, Moffitt RA (1980). The Use of Tobit Analysis. Rev. Econ. Stat. 62(3):18-320.
MoA (Ministry of Agriculture) (2014). Manual for Maize Technology Utilization (Amharic Version), Addis Ababa, Ethiopia.
Otitoju M, Arene J (2010). Constraints and Determinants of Technical Efficiency in Medium-Scale Soybean Production in Benue State, Nigeria. Afr. J. Agric. Res. 5(17):2276–2280.
Seyoum E, Battese G, Fleming E (1998). Technical Efficiency and Productivity of Maize Producers in Eastern Ethiopia: A study of farmers within and outside the Sasakawa- Global 2000 project. J. Agric. Econ. 19:341-348.
Shehu J, Iyortyer S, Mshelia I, Jongur U (2010). Determinants of Yam Productivity and Technical Efficiency among Yam Farmers in Benue State Nigeria. J. Soc. Sci. 24(2):143-148.
Shumet A (2011). Analysis of Technical Efficiency of Crop Producing Smallholder Farmers in Tigray, Ethiopia. MPRA Paper No. 40461, available online at http://mpra.ub.uni-muenchen.de/40461/.
Socio-Economic Profile of the Jimma Zone (2009). Government of Oromia Region, Jimma of Ethiopia.
UNDP (United Nation Development Program). 2013. Towards Building Resillence and supporting transformation in Ethiopia. Annual Report, 2013. www.et.undp.org.
Wambui B (2005). Technical Efficiency in Kenyan's Maize Production: An Application of the Stochastic Frontier Approach. M.Sc. Thesis, Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, Colorado.
Zerihun G (2003). Is Increased Instability in Cereal Production in Ethiopia Caused by Policy Changes? Contributed Paper Selected for Presentation at the 25th International Conference of Agricultural Economists, August 16-22, 2003, Durban, South Africa.


Journal of Development and Agricultural Economics
Related Journals Published by Academic Journals
■ Journal of Plant Breeding and Crop Science
■ African Journal of Agricultural Research
■ Journal of Horticulture and Forestry
■ International Journal of Livestock Production
■ International Journal of Fisheries and Aquaculture
■ Journal of Cereals and Oilseeds
■ Journal of Soil Science and Environmental Management
■ Journal of Stored Products and Postharvest Research
academicJournals