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Research Article

Exploring the Drivers of Maize Technologies Adoption Intensity: Empirical Evidence of Smallholders in SNNRP Region, Ethiopia

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Abstract

The productivity of Ethiopia's agriculture is still low despite the fact that policy makers have initiated and implemented programs to encourage farmers to use improved inputs in their production. This study explores what drives the smallholder farmers to use improved inputs (seed and fertilizers) in maize production. The data was collected through structured questionnaire that were pre tested to ensure the validity and objectives of the study under consideration. Descriptive statistics was used to describe the socio-economic characteristics of the households. Econometric model (Tobit) was used to identify factors that determining the intensity of inputs use among maize farmers. The result of Tobit model also shows that improved maize use intensity were influenced by tropical livestock unit, access to credit, distance to all weather roads, distance to the nearest market, membership to the cooperative, frequency of extension contact, and annual income. The use of chemical fertilizers namely Di-Ammoniate Phosphate use intensity for maize production was significantly influenced by family size, tropical livestock unit, and distance to the nearest market whereas the urea use intensity was significantly influenced by family size, distance to the nearest market, and annual income. The chemical fertilizers use intensity for maize production is by far below the recommended rate mainly urea. Hence, the study draw out that resource endowment, institutional and infrastructural factors would be enhanced to improve the intensity of maize technologies adoption.

Keywords: *Adoption; Inputs; Intensity; Tobit*

Introduction

Agriculture is the main source of income for many smallholder farmers in the developing world and plays an important role in economic growth, food security and poverty reduction [1]. Smallholder agriculture is identified as a vital development tool for achieving Millennium Development Goals [2]. However, in many developing countries, the majority of smallholder farmers rely on backward methods of production and low level of technologies utilization like use of local varieties, little use of fertilizers and pesticides that result to the low productivity and benefits [3]. Increasing agricultural productivity is critical to meet expected rising demand for the use of improved agricultural technologies that include all kinds of improved techniques and practices which affect the growth of agricultural output [4]. Income, nutrition, food price, employment opportunities and poverty has been associated with the adoption of improved agricultural practices (Kasirye, 2010). An improved agricultural technology that enhances sustainable production of food is therefore critical for sustainable food security and economic development. This has made the dynamics of technical change in agriculture to be an area of intense research [5]. These technologies are important to smallholder farmers in developing countries to makes them a priority for development efforts as they are constrained by many factors. These factors technological, infrastructure and institutions such as irrigation, markets (inputs and outputs), extension and credit services tend to be poorly developed [3,6].

Over decade, many authors have been studied the process and impact of technologies adoption on the smallholder farmers. However, improved agricultural technologies are often adopted slowly and several aspects of adoption remain poorly understood [7,8]. Maize is one of the most important cereal crops in Ethiopia. It forms an important part of the food and feed system and contributes significantly to income generation for rural households. According to 2017 districts office of agriculture and natural resource, the amount of improved maize varieties distributed were 792Qt in Misrak Azernet Berebere; 227.5Qt in Enemorena Ener; and 146.5Qt in Cheha district. The improved maize varieties distributed in the districts during that production season were BH-661; BH-660; BH-540; and pioneer. The distribution of maize varieties and others inputs like fertilizers have been made by governmental and non-governmental institutions however, there is limited study on the intensity of inputs use technologies adoption in the study areas. To this effect, the study was designed to assess the intensity of inputs use (seed and fertilizers) and identify factors that cause the level of inputs use variation among maize farmers in the study area.

Methodology

Description of the study areas

This study was conducted in two districts namely Misrak Azernet Berebere and Enemorena Ener of the CASCAPE project interventions area. The districts are known with suitable agro ecologies and production potentials for maize. Misrak Azernet Berebere is found in Silte zone and it is found at an altitude of 2097masl to 2699masl. The district received annual temperature that ranges from14 to 16°C. It has an area of 6,208 ha of cultivable land. The district constitutes 60% highland; and 40% midlands. In the midland kebeles of the district maize, teff and wheat are the major economic crops. Enemorena Ener is found in Guraghe zone. It is found at an altitude of ranges from 1001 to 3000masl. The annual rainfall ranges from 801 to 1400 ml and has received an annual temperature ranges from 12.6 to 25°C. The district has 58.53% highlands; 16.22% midlands; and 25.25% lowlands. The major crops grown in the midland kebeles of the districts are mainly maize and teff.

Data sources and sampling procedures

This study employed cross sectional data collected from both primary and secondary sources. The primary data was collected from selected households through structured questionnaire. Pre-test of the questionnaire was made to increase the validity and reliability of data thereby improves the content of the questions as per the objectives of the study. The data was collected with experienced and trained researchers. The types of data collected through structured questionnaire are household characteristics (age, sex educational status, family size, and farm experiences); resource endowments (farm size, livestock possession, income, irrigation use, and farm equipments); and institutional and infrastructural factors(extension contact, credit use, inputs use, membership of organization, distance to all weather road, and distance to the nearest market). Secondary data was used to support and strengthen the primary data which were taken from published (journals, articles, proceeding and central statistical authority) and unpublished (reports) source.

Multistage sampling procedures were used to reach the target households to be addressed for the study under consideration. In the first stage, districts are drawn purposively as the CASCAPE project interventions area and known with having suitable agro ecologies for maize production. In the second stage, four peasant associations were also purposively selected for this study as they are the only kebeles that had made tremendous effort on maize crop by the project. With the collaboration of respective peasant associations development agents, the lists of households were identified and from each kebeles based on proportional to the sample size 170 farmers were randomly selected.

Analytical framework

The study employed Tobit model to analyses factors affecting the adoption intensity of improved maize varieties and fertilizers among maize growers in the study areas. This Tobit model [9] used to tests the factors affecting the intensity of inputs use for maize production. The specification of the three dependent variables used in this study is as follows:

$$\text{Maize use intensity} = \frac{\text{area covered by improved maize variety}(ha)}{\text{total area covered by maize both improved and local variety }(ha)} \ldots (1)$$

$$\text{DAP use intensity for maize} = \frac{\text{Actual DAP rate }\left(\frac{kg}{ha}\right)\text{ for maize}}{\text{Recommended DAP rate}\left(\frac{kg}{ha}\right)\text{ for maize}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ldots (2)$$

$$\text{Urea use intensity for maize} = \frac{\text{Actual Urea rate }\left(\frac{kg}{ha}\right)\text{ for maize}}{\text{Recommended Urea rate}\left(\frac{kg}{ha}\right)\text{ for maize}} \ldots\ldots\ldots\ldots\ldots\ldots\ \ldots\ldots (3)$$

Maize adoption use intensity= f(sex, education, family size, farm experience, number of oxen, TLU, farm size, extension contact, credit access, distance to all weather roads, distance to the nearest market, membership to cooperative, annual income and dependency ratio).

The dependent variable in the model is index value ranging from 0 to 1. A value of 0 indicates non-adopter, index value 1 represents the full adopter of the technology component (adopted without discontinuity), and the values between 0 and 1 indicate the level of the adoption within the range of the Tobit Model Limit. STATA-12 was used for data management and analysis.

Result and Discussions

Descriptive statistics of socioeconomic characteristics of the households

Table 1 presents the descriptive statistics of the socioeconomic characteristics of the households. Accordingly, 95.29% of the respondents were male. The average age of the household head included in the study was 46.87 years and the minimum age in the sample was 22 years, while the maximum age was 80 years. In terms of education the study reveals that 78% of the respondents were literate. The average number of family size owned the households was about 7.68 whereas the average land size owned by the respondent was 1.5 hectare. Regarding the livestock possession of the respondents, the average number of livestock tropical unit was 6.68 whereas on average the household head was owned 0.83 number of ox. The result also shows about 81% of the respondent was received extension training and about 56.5% of the respondents had credit accessed either in cash or kinds. The study also indicates about 69% of the respondents were membership to cooperatives. The average distance travelled by the respondents from their home to the all-weather roads were about 1 kilometers whereas on average they travelled about 4 and 12.25 kilometers to the nearest market and woreda market respectively.

Variable	Mean (St.dev)	Minimum	Maximum
Gender of the household head (1 = male)	0.95 (0.212)	0	1
Age of the household head (years)	46.870 (12.253)	22	80
Education of the household head (1 = literate)	0.782 (0.413)	0	1
Family size (numbers)	7.682 (2.980)	2	23
Household farm experience (years)	25.627 (12.675)	2	65
Farm size (hectare)	1.521 (1.340)	0.125	14
Tropical Livestock Unit	6.688 (6.605)	0	63
Number oxen	0.852 (1.063)	0	7
Extension training (1 = yes)	0.811 (0.392)	0	1
Credit access (1 = yes)	0.564 (0.497)	0	1
Distance to all-weather roads (km)	1.010 (1.249)	0.01	5.5
Distance to the nearest market (km)	4.053 (3.106)	0.02	15
Membership to cooperative (1 = yes)	0.692 (0.462)	0	1
Annual income (000 Birr)	12.661 (19.754)	0	163
Dependence ratio	0.840 (0.735)	0	4
Area covered improved maize (ha)	0.1802 (0.1847)	0	1.25
DAP actual use (kg/ha)	65.47 (29.64)	0	120
Urea actual use (kg/ha)	53.77 (32.96)	0	106

Table 1: *Descriptive statistics of the socio-economic variables of the households.*

The inputs use of the households for maize production was also depicted in table 1. The average area of land allocated for improved maize was of the total 0.18 ha and the maximum area covered with improved maize was 1.25 ha. Regarding to the households use of fertilizers for maize production is found to be far below the national recommendation rate. The average actual amount of DAP applied for maize was 65.5 kg/ha whereas the actual amount of urea fertilizer applied was 53.78 kg/ha.

Tobit model for maize inputs use adoption intensity

Hereunder, Tobit model was estimated for improved seed, DAP and urea use intensity for maize production by smallholder farmers as presented in table 2. The log-likelihood ratio test for maize use intensity, DAP use intensity, and urea use intensity were all significant at p < 0.01. The result shows that the improved maize adoption intensity was significantly influenced by TLU, distance to all-weather roads, distance to the nearest woreda market, cooperative membership, extension contact, and annual income of the households. Moreover, the intensity of DAP fertilizer use for maize was influenced by family size, TLU, distance to the nearest woreda market whereas the urea fertilizer use intensity of the households was influenced by family size, distance to the nearest woreda market, and annual income.

Variables	Improved maize use intensity		DAP use intensity		Urea use intensity	
	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Gender of the household head (1 = male)	-0.1142	0.12334	-0.0915	0.11355	0.06735	0.08454
Education of the household head (1 = literate)	0.08113	0.08748	0.01753	0.05866	0.01455	0.03208
Family size (numbers)	-0.0014	0.013	-0.0171*	0.00935	*-0.011***	0.00506
Household farm experience (years)	-0.0038	0.00277	-0.0016	0.00239	-0.0017	0.00124
Number oxen	0.03823	0.02656	0.01279	0.02681	-0.0104	0.0158
Tropical Livestock Unit (TLU)	0.0098**	0.00432	0.0083**	0.00342	0.0002	0.00201
Farm size (hectare)	-0.0365	0.03161	-0.006	0.0193	-0.0076	0.01022
Credit access (1 = yes)	-0.1306	0.05739	-0.0411	0.04603	-0.0251	0.02994
Distance to all-weather roads (km)	-0.03537**	0.01747	0.00399	0.01641	0.00606	0.00954
Distance to the nearest market (km)	-0.0138***	0.00444	-0.012***	0.00367	-0.009***	0.0021
Membership to cooperative (1 = yes)	0.13768*	0.07929	-0.0012	0.05816	0.01072	0.03668
Frequency of extension contact (high)						
Medium	-0.1607***	0.05552	-0.0232	0.04861	-0.0332	0.02919
Low	-0.2524	0.15273	-0.0584	0.09681	-0.0434	0.05783
Annual income (000 Birr)	0.00325**	0.00166	0.0001	0.00131	0.0011*	0.00065
Dependence ratio	-0.0945	0.0401	-0.0273	0.03453	-0.0294	0.01922
_cons	1.30294	0.17701	1.05219	0.14631	0.46798	0.10432
/sigma	0.3492	0.03153	0.27994	0.01568	0.16339	0.0101

Table 2: *Determinants of inputs use intensity for maize production.*

, ** and * implies the level of significance at 10, 5 and 1% respectively.*

Family size

The results of Tobit model reveal that the coefficient of family size for improved maize variety and fertilizers use intensity were negative. The intensity of fertilizers (both DAP and urea) use were also statistically significantly influenced by family size at 10% and 5% significance level for DAP and urea respectively. Addition of one more family members leads to a decrease of the DAP and urea use intensity by 1.7% and 1.1% respectively. This implies that if the household own larger family size that mainly depends on the household head, obviously they incur more expenditures(education, foods and medication) that in turn decreases the intensity of fertilizers use for the crop. Beside this, the cost of inputs (seed and fertilizers) becomes too high for smallholder farmers that push them to use the fertilizers below the recommended levels.

TLU

Livestock holding found to influences the intensity of improved maize and DAP use and positively and statistically significant at 5% significance level. A unit increase in the TLU leads to an increase in the intensity of adopting improved maize by 0.98% and the intensity of DAP fertilizer adoption by 0.83%. Hence, livestock is considered as a proxy for measuring wealth status of household that indicates farmers with large number of livestock are better the intensity of adopting the improved maize and fertilizer (DAP). This is because households with relatively more livestock make use of the income obtained from livestock for the purchase of improved seed and fertilizer for maize cultivation. This finding is in line with Hailu [10], Solomon., *et al*. [11] and Hassen., *et al* [12].

Frequency of extension contact

The frequency of extension contact for this study was categorized as high, medium and low. The result of the model show that those households who had medium extension contact decreases the intensity of improved maize adoption as compared to those who had received high extension contact. As household moved received medium to high extension contact the intensity of improved maize adoption increased by 16.07%. This implies that the intensity of improved maize adoption increases with more extension visits. Extension is a form of human capital and households endowed with such capital are likely to have greater farm management capacity or ability to understand and use new technologies. The level of awareness and knowledge regarding the use of improved technologies for smallholder farmers enhanced with higher interaction between the farmer and extension agents. This is consistent with Assefa and Gezahegn [13] and Shiferaw and Tesfaye [14].

Distance to the nearest market was found to be statistically significant and negative influence the intensity of improved maize use, DAP and urea use intensity at 1% probability level. These implies that the a one kilometer increase of the distance between farmers' home and the nearest market center would lower the intensity of adopting improved maize varieties (1.38%), DAP (1.2%) and urea (.9%). Distance to market is assumed to play an important role in technology adoption. Input and output markets are also known to influence the adoption of improved agricultural technologies. Farmers closer to the markets had a high probability of using improved maize and fertilizers. This result is similar with Reardon., *et al*. [15] finding. Thus, improving farmers' access to markets points has a potential of enhancing technologies adoption. This might be the fact that relative proximity to market reduces marketing cost and increases the opportunities for technologies options. This result is consistent with Tesfaye and Alemu [16] and Kebede [17].

Distance from all weather roads has a negative and significant relationship with adoption of improved maize variety at five percent levels of significance. This indicates that farmers who are far away from all-weather roads are less likely to adopt improved maize than those who are closer. This is because farmers who are far away from all-weather roads face greater transaction and transport costs, and lack extension information provided by extension agents and the less adopter of improved technologies. One more kilometer distance to the all-weather roads decreases the probability of adopting improved maize variety by 3.5 percent and it is in line with [12].

Membership to cooperative

Cooperative membership also appears to positively influence the intensity improved maize adoption. It was statistically significant at 10% level. Being to membership of cooperative would increase the intensity of improved maize varieties use by 13.77%. This implies that farmers in cooperatives membership tend to adopt improved maize faster than farmers who are not members. Membership to cooperative makes farmers to have more access to input, information and better interpretation of available information related to new technology. The more the respondents join farmer's association, the more the hectares of land cultivated with improved maize varieties. This finding is consistent with Akinola., *et al* [18].

Annual Income

Household annual income was positively and statistically significant in determining the intensity of improved maize and urea use at 5% and 10% significance level respectively. This implies that the more the income realized from off farm, farm and livestock the more the hectares of land cultivated with improved maize and the more urea fertilizer used. An increase in the household annual income increases the intensity of improved maize and urea use. This may be due to the fact that more money is available to acquire inputs like seed and fertilizers [19].

Conclusion and Recommendation

The study was designed to identify the intensity of improved seed and fertilizers use for maize production among smallholder farmers. The results of analysis show that the average area covered by improved maize was 0.18ha; and the actual amount of fertilizers application was low as compared to national recommendation. The result of Tobit model revealed that improved maize use intensity among smallholder farmers were influenced by tropical livestock unit, distance to all weather roads, distance to the nearest market, membership to the cooperative, frequency of extension contact, and annual income. DAP use intensity for maize production was significantly influenced by family size, tropical livestock unit, distance to the nearest market whereas the urea use intensity was significantly influenced by family size, distance to the nearest market and annual income.

The study concluded that the intensity of adoption of inputs use was driven by a mixes of socioeconomic factors such as endowments (family size, tropical livestock unit and annual income); infrastructural (distance to all weather roads and distance the nearest market); and institutional (extension service and membership to cooperative). Thus, efforts should be directed towards strengthening the frequent extension contact to promote the dissemination of agricultural technologies which has the potential to increase the intensity of use of improved maize. Membership of farmer cooperatives is important to strengthen the existing farmer cooperatives to reinforce farmer-to-farmer knowledge sharing through providing awareness creation, incentives and providing various facilities by the regional and local government.

The size of livestock owned had a significant positive influence on the adoption intensity of improved maize and DAP fertilizer. Hence, the study suggested strengthening the existing livestock productivity. Annual income of the household has increased the intensity of improved maize use and urea fertilizer. This may be due to the fact that more money is available to acquire more seeds and associated inputs.

Distance to all weather roads and distance to the nearest market would found to influence the intensity of technologies adoption for maize production. This enables farmers to buy farm inputs at lower prices. Thus, more effort is needed in expanding roads and maintenance of the available roads in rural areas.

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