Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.9, No.15, 2018

Factors Influencing Intensity of Adoption of Improved Highland Maize Varieties: The Case of Toke Kutaye District, West Shewa Zone, Oromia Regional State, Ethiopia

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Abstract
Improved highland Maize is a new and promising crop gradually becoming important in the highlands of Ethiopia. Its production is rapidly increasing in the highland parts of the country where it has been a minor crop in the past. The empirical evidences on the determinants of agricultural technology adoption and their intensity of adoption are very limited. In this paper, determinants of adoption and intensity of adoption of improved highland maize varieties were investigated by using descriptive statistics and econometric model (Tobit). Two stage sampling procedure was followed in order to draw 150 sample respondents. The model result revealed that variables such as farm size, household income, access to credit, contact with extension agents, participation in training, and field day were positively and significantly influenced whereas, age of household and market distance negatively influenced adoption and intensity of use of improved highland maize varieties production in the study area. Therefore, government policies and intervention on adoption and intensity use of agricultural technology should pay attention and move along those variables significantly influencing adoption and intensity of use of new agricultural technology.
Keywords: Adoption, Intensity, Highland Maize, Technology, Tobit model, Ethiopia.

1. INTRODUCTION

1.1. Background of the Study

Maize is the most widely grown and consumed staple crop in Africa with more than 300 million Africans depending on it as their main food source. It is the staple food for 24 million households in east and southern Africa and is annually planted over an area of 15.5 million hectares. Research in to maize improvement practices to optimize grain yields is a priority for governments in the region because of the critical role the crop plays in ensuring food security [2].

In Ethiopia's economy Agriculture continues to be the dominant sector, accounting for 51% of the GDP in 2009 [20]. Within agriculture, cereals play a central role accounting for roughly 60% of rural employment, 80% of total cultivated land. Among cereals, maize is the most important crop in terms of production and contributes significantly to the economic and social development of Ethiopia [5]. In the country out of the major cereal crops, maize ranks second to teff in area and first in production and per capita consumption of maize is 60 kg/year, Ethiopia. Therefore, highland improved maize production is crucial for Ethiopian people in the short and medium term food security, and as well as for GTP growth [13].

Although a substantial quantity of maize is produced in the lowland areas, predominantly maize is grown in the most productive agricultural lands in the mid and highland areas of the country [6]. The high altitude, sub-humid maize agro-ecology (1800-2400 m.a.s.l) in Ethiopia is estimated to cover 20% of the land devoted to annual maize cultivation. More than 30% of small-scale farmers in this agro-ecology depend on maize production for their livelihoods [18]. To meet the needs of increasing maize production in the highlands of the country, the Highland Maize Breeding Program was established at the Ambo Plant Protection Research Center (APPRC) of the Ethiopian Institute of Agricultural Research (EIAR) with the support of the International Maize and Wheat Improvement Center (CIMMYT), in 1998.

It is aimed at developing and popularizing improved Highland maize cultivars, and enhancing their crop management technological packages. From 1999 to 2011, the breeding program released five superior Highland maize hybrids including: AMB02SYN1-'Hora', AMH800-'Arganne', AMH850-'Wenchi', AMH851-'Jibat', and MH760Q-'*Webi*', for large-scale production [6]. AMH760Q was identified as quality protein maize (QPM) hybrid, which was developed from the most popular, top-yielding non-QPM hybrid 'BH660'. Over 5.8 million hectares of potential suitable land was identified for the highland maize hybrids in the country ([7], [8]).

Toke kutaye district have a major potential in highland maize varieties production. The land use pattern of the district shows that 37,509 ha is cultivated land but improved highland maize has not been adopted by farmers. Therefore, this study was intended to identify factors influencing adoption and intensity of use of improved highland maize varieties.

1.2. Statement of the Problem
Maize plays a major role in the livelihood and food security of most smallholder farmers in Sub-Saharan African countries including Ethiopia. Maize is grown in most parts of the country with different agro-ecological suitability and productivity potentials. Data from [5] shows that, during the 2009/10 production year, Ethiopia produced 3.89 million tons of maize on 1.77 million ha of land.

High land maize is one of the major food crops where research brought tangible improvement in production and productivity. However, in sub-humid agro-ecology, smallholder farmers' knowledge and use of agricultural technologies in general and improved highland maize varieties in particular, are limited ([18]; [6]). In the study area, the highlands hybrids maize has not been violently accepted, and not adopted by farmers this is why the current study aimed in identifying factors that influence adoption and intensity of use of improved highland maize varieties and exploring farmers' perception towards this technology in the study area.

1.3. Objectives of the study
1.3.1. General Objective
The overall objective of this study is to assess factors influencing intensity of adoption of improved Highland maize varieties in the selected kebeles of Toke kutaye district
1.3.1. Specific Objectives
- To analyze intensity use determinants of improved highland maize varieties in the study area
- To provide policy recommendation towards improved highland maize varieties

2. Empirical Studies on the Adoption of Agricultural Technologies
Adoption of new agricultural technology has attracted the attention of development economists and policy makers nowadays since it is believed that introduction of new technology increases production and productivity and technology transfer helps to achieve economic growth for economic developing countries [9]. Analysis of intensity adoption for new technology require careful evaluation of a large number of technical, political and socio-economic factors to identify determinants of whether and when farmers adoption decision takes place.

The history and economics of diffusion and adoption of agricultural technologies began in the mid-age of 1957 where the process and models of adoption have been studied by different scholars, with the most popular and widely used being that of Everett Rogers, titled diffusion of innovations [17], which spans the disciplines of economics, technology, education, political science, public health, history and communications.

In the literature, technology and innovation are sometimes used interchangeably. While the process by which a new technology or innovation is transmitted through certain media over time to members of society is referred to as diffusion, the rate at which a new or emerging technology is adopted depends on some important attributes of the technology including the perceived advantages relative to existing ones and its compatibility with existing needs and values of the society or potential adopter, simplicity (ease of understanding and use), trial ability for potential adjustment, and observability [16].

Adoption of improved agricultural technologies has been traced to the success of the Green Revolution initiated by an American scientist, Norman Borlaug, in Mexico in the 1940s [7]. The Green Revolution enhanced the adoption of high-yielding crop cultivars and inputs such as fertilizer and irrigation, which resulted in increased food production [13]. Improved high-yielding crop varieties developed during the revolution produced high yields with the help of fertilizers and irrigation systems, which provide water for farming in areas with little or no rainfall, thereby putting more land to use for food production [4] Results of some empirical studies [12] underscore the potential of improved agricultural technologies in enhancing productivity, income, and overall economic growth.

The potential benefits of a new technology can only be realized when it is adopted and used; the adoption decision involves a critical comparison of perceived benefits and costs associated with the technology [19]. A better understanding of the diffusion, adoption, and impact of improved technologies will guide producer groups, research institutions, and policy makers in making prudent and informed decisions about allocating resources for technology development.

Some studies that examine agricultural new technology adoption and level of adoption intensity have been carried out, particularly in developing countries like that of [14]. [1] used probit and random effect models to examine the influence of farmer learning and risk on the likelihood and intensity of adopting improved teff and wheat technologies in northern and western Showa zones of Ethiopia. The study underscores the importance of learning and experience as drivers of continued technology adoption. Results indicate that awareness, timely availability, and profitability of new teff and wheat varieties enhanced farmers' learning and experience. This positively influenced adoption of the new technologies.

[7] employed an average treatment estimation (ATE) framework to examine the adoption rate and determinants of adoption of new rice variety for Africa (NERICA) in Gambia. Results of the study show that the adoption rate stood at 40% against anticipated rate of 83% due to lack of information about and access to

NERICA, thereby suggesting the need for the supply and distribution of more NERICA to farmers for easy access, experience, and adoption. In another study carried out in Africa, [19] looked at the factors influencing agricultural technology adoption by rural households in Mozambique.

Attended a higher level of education, and are members of agricultural associations have a higher probability of adopting new agricultural technologies. Learning through networks has been identified as a factor that influences technology adoption. For example, [3] examined the role of social networks and how the adoption choices of network members influence a farmer's adoption decision in Northern Mozambique. They found that farmers who discuss and/or learn about new technologies within their social network have a greater tendency to adopt. However, this result cannot be generalized.

As stated earlier, the technical opinion of social network leaders on a particular technology affects adoption by members of the social network. If the leader's opinion is not in favour of the new technology, members may not adopt. [21] used an extension service is an important component of adoption that motivates potential adopters to be profitable. [15] estimated the time and costs involved in the process of developing a new plant biotechnology from discovery to authorization by regulatory authorities, fuelling the debate as to whether the time and costs associated with the development of a new technology. Technological advancement and adoption are relevant for improvements in every sector.

In recent years, there has been an increase in funding for agricultural research and development in technological innovations, particularly by the private sector. This has yielded positive returns on investment. However, significant adoption and commercialization of emerging technologies has not been achieved, particularly in less-developed countries, due to a combination of cultural beliefs, ethical concerns, regulatory delays, and lack of information and understanding of the science and technology being used. This has put consumers and producers in a dilemma. Although significant improvements have been made in technological advancement, more is needed to better understand the root causes of low adoption rates, especially in developing countries [15].

3. METHODOLOGY

3.1. Description of the Study Area

The study was conducted in Toke Kutaye district which is located about 128 km west of Capital city of Ethiopia-Addis Ababa and 12 km west direction of Ambo Town. Geographically, the district lies between $8^0$47' to $9^0$21 latitudes and $37^0$32 to $37^0$03'E longitude. The district has meant annual rainfall of 1100 mm with annual mean temperature of 19.5^0C, the main rainy season of the district is from May to September and elevation ranging from 1500 to 2000 m above mean sea level.

Administratively, the district made up of 24 kebeles (20 rural and 4 urban kebeles). The total population number of the study area is 134,767 (66,492 males and 68,275 female). There are 22,895 household head farmers on average land size of 788.87 km^2. The land use pattern of the district shows that 37,509 ha is cultivated land; 3651 ha is covered with forest, 11,603 ha is grazing land and 26,124 ha with bush and shrubs. The major crops produced in the district are Teff, Maize, wheat, Sorghum and barley.

3.2. Sampling procedure and sample size determination

Two stage sampling techniques were employed to select the sample respondents. First stage was purposive selection of highland maize growing Kebeles of the districts, followed by selection of sample households. The Kebele identification was made through reviewing secondary data on production potential of maize and dissemination of the improved highland maize technologies and area coverage of the crop. In the second stage 150 sample respondents were chosen using systematic random sampling technique from each kebeles based on probability proportional to size through using the following formula of sample determination:

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

$$n = \frac{3954}{1+3954(0.08)} \approx 150$$

Where n is the sample size for the study, N is the total households of the study area which is 3954, *e* is the maximum variability or margin of error or which is 0.08 in this study, 1 is the probability of the event occurring. The sample size from each kebeles' was determined based on their proportion to total share of households residing in each kebeles.

Table 1: Sample size determination

No.	Sample kebeles	Households	Sample size
1	Kolba anchabi	550	21
2	Maruf	1031	39
3	Dadagalan	1123	43
4	Imala Dawo Ajo	1250	47
	Total	**3954**	**150**

Source: Author's compilation, 2017.

3.3. Econometric Model Specification

Tobit model is an extension of the probit model and it is really one approach to dealing with the problem of censored data. This model was chosen because; it has an advantage over other analytical models in that, it reveals both the probability of adoption and intensity of use of the technology [10]. So, Tobit model is more appropriate to give reliable output of both discrete and continuous variable combination.
The Tobit model ([11]; [10]), which tests factors affecting adoption and intensity of adoption improved highland maize varieties production, can be specified as follows:

$Y^*=\beta_0+\beta ixi+Ui$
$Y=Y^*$ if $\beta_0+\beta ixi+Ui > 0$………………………………………………………………….. {2}
$Y_i=0$ if $\beta_0+\beta ixi+Ui < 0$

Where,

Y_i= the observed dependent variable
Y^*= latent variable (which is not observable)
X_i = Vector of explanatory variable
β = vector of parameters to be estimated
U_i = an independent normally distributed error term with zero mean and constant variance

The model parameters are estimated by maximizing the Tobit likelihood function of the following form [11].

$$L=\prod_{Y_i^*>0}\frac{1}{\sigma}f\left(\frac{Y_i-\beta_i X_i}{\sigma}\right)\prod_{Y_i^*\le 0}F\left(\frac{-\beta_i X_i}{\sigma}\right)$$

Where f and F are respectively, the density function and cumulative distribution function of Y_{i^*}, $\prod_{yi^*}>0$ means the product over those i for which $y_{i^*}>0$, and $\prod y_{i^*}\le 0$ means the product over those i for which $y_{i^*}\le 0$.

The interpretation of Tobit model coefficients is the same with that of uncensored linear model coefficients. The significant variables do not all have the same impact on the adoption of improved high land maize varieties. Hence, one has to compute the derivatives of the estimated Tobit model to predict the effects of changes in the explanatory variables. That is probability and intensity of the adoption of improved maize seed. As cited in ([10]; [11]) proposed the following techniques to decompose the effects of explanatory variables into adoption and intensity effects.

Thus; change in Xi (explanatory variables) has two effects. It affects the conditional mean of *Yi* in the positive part of the distribution, and it affects the probability that the observation will fall in that part of the distribution. Similarly, in this study, the marginal effect of explanatory variables will be estimated as follows. This procedure was used in this study,

- The marginal effect of an explanatory variable on the expected value of the dependent variable is:

$$\frac{\partial E(Y_i)}{\partial (X_i)}=F(z)\beta_i \quad \ldots\ldots \{3\}$$

Where, $\frac{\beta_i X_i}{\sigma}$ is donated by Z, following Maddala (1997)

The Change in the probability of adopting a technology as independent variable Xi change is:

$$\frac{\partial F(z)}{\partial X_i}=f(z)\frac{\beta_i}{\sigma} \quad \ldots\ldots \{4\}$$

- The change in the intensity of adoption with respect to a change in an explanatory variable among adopters is estimated by:

$$\frac{\partial E\left(Y_i / Y_i^* \succ 0\right)}{\partial X_i} = \beta_i \left[1 - Z\frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)}\right)^2\right] \quad \text{...} \{5\}$$

Where,
F(z) is the cumulative normal distribution of Z, f (z) is the value of the derivative of the normal curve at a given point (i.e., unit normal density), Z is the z-score for the area under normal curve, is a vector of Tobit maximum likelihood estimates and σ is the standard error of the error term. Using descriptive statistics it is also possible to clearly compare and contrast different characteristics of the sample households along with the econometric model.

3.4. Hypothesis and Definition of Variables

Dependent variables

The dependent variable used in the Tobit model was adoption of improved highland maize varieties and intensity of adoption which is treated as a continuous variable. It is the amount of improved highland maize varieties that the farmer used which is measured in Kilogram.

Table 2: Hypothesis and Descriptions of the Variables

Variables	Symbols	Unit	Sign	Descriptions of the Variables
Age of HHHs	AGEHH	Years	-	Number of years
Education level	EDULEVEL	Years	+	Schooling years
Farm Income	INCHH	Birr	+	ETB
Credit accessibility	CREDIT	Dummy	+	Dummy: 1=if access credit; 0= otherwise
Extension Contact	CONTEXA	Dummy	+	Dummy: 1=if frequency of extension contact; 0= otherwise
Field Day	PARTIFIDA	Number	+	Dummy: 1=if yes; 0= otherwise
Training	PARTRAI	Number	+	Dummy: 1=if yes; 0= otherwise
Labor availability	FAMILAB	Man equi.	+	Man equivalent
Market distance	MARKDIST	Kilometer	-	Kilometer
Livestock	LIVESHLG	TLU	+	TLU
Cosmopolitan	COSMOP	Dummy	+	Dummy: 1=if yes; 0= otherwise
Farm size	FARMSIZ	Hectare	+	Hectare
Social organization	PARTORG	Dummy	+	Dummy: 1=if yes; 0= otherwise

Source: Author's compilation, 2017.

4. RESULTS AND DISCUSSIONS

4.1. Results of Descriptive statistics

In this study, a total of 13 explanatory variables were identified and out of these variables 9 of them revealed significant association with the adoption and intensity of use of improved highland maize varieties. Variables such frequency of contact with extension agents, access to credit service, social organization, participation in training, Field day and cosmopolitans are dummy, whereas age of household, farm income and farm size are continuous variables that show statistically significant at 1% and 5% significant level with the adoption decision. Differently, education level, livestock holding, market distance and labour availability, had not statistically significant relation with the adoption decision. Summary of the overall descriptive results of this study is presented in table 3 and 4 below.

Table 3: Results of Descriptive Statistics for Continuous Variables

Variables	Adopters (N=104)		Non-adopters (N=46)		t-value	P- value
	Mean	Standard deviation	Mean	Standard deviation		
Age of HH	46.89	9.57	54.17	8.43	4.45	0.00***
Education level	1.98	0.87	2.04	0.81	0.41	0.67
Farm size	1.12	0.221	1.206	0.23	2.08	0.04**
TLU	6.28	2.884	6.5	3.07	0.37	0.7
Farm Income	8937.8	2828.3	4629.7	2630.6	-8.78	0.00***
Labor	4.87	1.3045	5.009	1.13	0.61	0.55
Market distance	2.44	1.01	2.4	1.0	-0.16	0.87

Source: own survey data, 2017. ***, **, Significant at 1 and 5 % probability level respectively

Table 4: Results of descriptive statistics for Dummy Variables

Variables response	Adopters (N=104)		Non-adopters (N=46)		X^2- value	P -value
	Frequency	Percent	Frequency	Percent		
Credit availability						
Yes	91	87.5	4	8.7	85.3***	0.000
No	13	12.5	42	91.3		
Social Organization						
Yes	38	36.54	42	91.3	38.43***	0.000
No	66	63.46	4	8.7		
Access to Extension						
Yes	103	99.04	24	52.2	60.23***	0.000
No	1	0.96	22	47.83		
Participation in Training						
Yes	33	31.73	1	2.17	15.86***	0.000
No	71	68.27	45	97.83		
Participation in Field day						
Yes	83	79.81	15	32.61	31.37***	0.000
No	21	20.19	31	67.39		
Cosmopolitans						
Frequently	46	44.23	45	97.83	38.39***	0.00
Not frequently	58	55.77	1	2.17		

Source: own survey data, 2017. *** Significant at< 1 % probability level respectively

4.2. Econometric Model Results

An econometric (Tobit) model was used to determine the influence of various personal, demographic, socio-economic, institutional and psychological variables on adoption and intensity of use of improved highland maize production varieties.

The estimates of parameters of the variables expected to influence adoption of improved highland maize varieties are displayed on Table 5. Thirteen explanatory variables of which 6 are dummy and 7 variables are continuous were taken to the model for analysis. The impact of these variables on the dependent variable is discussed below.

Age: found to be significant at 5 percent level with negative relationship. A year increase in the age of the respondent reduces probability of adoption and intensity of use by 0.7 percent. This implies that the older the respondent, the lower the probability of adoption.

Farm Size: had statistically significant influence at 1 percent level on adoption and intensity of use of improved highland maize varieties which means that an increase in farm size by 1 ha increases the probability and intensity of use of improved highland maize by 4.03 percent; that implies household with larger land holdings allocated more land to improved highland maize varieties production.

Market distance: found to be negatively and significantly associated with the probability of adoption and intensity of use of improved highland maize technology at less than 5 percent. The result indicates that, as the house of the farmer is far by kilometer from main market, the probability of adoption and intensity of use of highland maize varieties decreases by 0.5 percent. The implication of this negative relationship is that if the distance between farmers' living home and the market area is longer, the farmers will be discouraged from adopting improved highland maize varieties.

Contact with extension agents: found to be positive and statistically significant variable in determining adoption and intensity of use at 5 percent level which implies an increase in contact with extension agent increases probability and intensity of adoption of IHM varieties production by 2.8 percent. This is due to the fact that, frequency of contacts with extension agents increases the probability of acquiring up-to-date information on the new agricultural technologies.

Access to credit Services: found to be positive and significant influence on the likelihood of adoption and intensity of use of improved highland maize technology at 1 percent significance level. The results computed indicated that increase having access to credit by 1 percent increases the probability of adoption and intensity of use of improved highland maize varieties by 3.98 percent respectively. This is due to the fact that access to credit service commands the farmers' financial resources to buy inputs for improved highland maize production. With the availability of credit a household can purchase improved seed and hire extra labour.

Participation in Farmers' Field day: is positively and significantly related to adoption and intensity of use of improved highland maize production technology at 1 percent level of significance. A marginal change in number of participation in field day visits increases probability of adoption and intensity of adoption of improved highland maize by 2.4 percent. Field day is an important method of extension to pull farmers in accepting technologies.

Participation in Training: is positively and significantly related to adoption and intensity of use of improved highland maize variety at 1 percent significant level. The marginal effect result indicates that an increase in participating training by 1 percent increases the probability of adoption and intensity of use of the varieties production 2.8 percent respectively which implies farmers who participate in training will be more likely to adopt new technology than otherwise.

Generally, the model results of this study revealed that a unit increase in explanatory variable will bring certain percent of change or increase on the probability and intensity of adoption of improved highland maize production. Therefore, the current government intervention has to give more emphasis to work on improving the affecting factors of improved highland maize production.

Table 5: Maximum Likelihood Estimates of Tobit Model

Log likelihood = -257.12			Number of observation = 150 Prob>chi2 = 0.000 LR chi2(13) = 208.42 Pseudo R2 = 0.2884		
Variables	**Estimated Coef.**	**Std. Err.**	**t-ratio**	**P-Value**	**Change in probability** $\frac{\partial F(z)}{\partial X_i} \approx f(z)\frac{\beta_i}{\sigma}$
Constant	-7.534188	2.853968	-2.64	0.009	
AGEHH	-0.075828	0.0294787	-2.57	0.01**	-0.667928
EDULEVEL	0.287353	0.3148265	0.91	0.363	0.2531131
FARMSIZ	4.583338	1.186035	3.86	0.00***	4.037192
TLU	-0.06053	0.0987964	-0.65	0.519	-0.0533172
INCHH	0.000326	8.69E-05	3.75	0.00***	0.0002872
LABOR	-0.16429	0.2214025	-0.74	0.459	-0.144722
PARTORG	0.19413	0.6289705	0.31	0.758	0.1708918
MARKDIST	-0.55405	0.2463733	-2.25	0.026**	-0.488026
CONTEXTA	3.78084	1.638886	2.31	0.023**	2.778958
CREDIT	5.07123	0.8379452	6.05	0.00***	3.976482
PARTIFID	2.8556	0.6473491	4.41	0.00***	2.372887
PARTRAI	3.04901	0.6610033	4.61	0.00***	2.81298
COSMOP	-0.8872	0.5399329	-1.64	0.103	-0.7868346

Obs. summary: 46 left-censored observations at DV<=0
104 uncensored observations
0 right-censored observations
Source: Own estimation result, ***, ** represents 1%, and 5% level of significance respectively.

5. CONCLUSIONS AND POLICY IMPLICATIONS

5.1. Conclusions

The level of adoption observed is an indication of the existence of substantial potential to improve smallholders' productivity with minimum cost compared to the development and introduction of new technologies. As repeatedly stated improved highland maize varieties production is important in solving food security and poverty problems in agriculture-based economies. The study result revealed that farm size, household income, access to credit, contact with extension agents, participation in training, and field day were positively and significantly influenced. Although, the institutional support provided to the farmers, such microfinance service, research and technology transfer was not to the expected level.

5.2. Policy implications

The adoption and intensity of use of improved highland maize varieties affected by several household personal, demographic and socio-economic factors together with positively and significantly influenced study variables which can consequently affect the production and productivity of smallholder farmers. Therefore, policy makers and government intervention related with agricultural technology transfer should take significantly influenced variables into consideration.

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