Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.12, No.23, 2022

Determinants of Adoption and Intensity of Adoption of Improved Maize Varieties in Babile and Fedis Districts of East Hararghe Zone, Oromia Regional State, Ethiopia

Solomon Ayele* Kibret Ketama Husein Abro
Socio-Economics Research Team, Fedis Agricultural Research Center of Oromia Agricultural Research Institute, Harar, Ethiopia, P.O. Box 904
*Authors e-mail:- solomon4ayele@gmail.com, kebret2012@gmail.com, hhnn2004@gmail.com

Abstract
Increasing agricultural productivity and improving the sustainable livelihoods of rural farmers are among the government of Ethiopia policy priorities. In this effort, adoption of improved agricultural technologies is expected to play a vital role. However, the uses of improved maize varieties are constrained by various factors. Hence, in this study, an attempt was made to examine determinants of adoption and intensity of adoption of improved maize varieties. A multi-stage random sampling technique was employed to select 218 sample households from both Babile and Fedis Districts using cross-sectional data. Double-hurdle econometric model was used to identify determinants of households' adoption decision and intensity of adoption of improved maize varieties. The model results showed that age of household head, level of education of household head, farm experience in maize production, total farm size owned, access to extension services, improved maize seed availability, the distance nearest market and districts dummy were significantly determined the adoption of improved maize varieties in the first hurdle model (probit). In the second hurdle (truncated), sex of household head, age of household head, family size, farm experience, total farm size owned, districts dummy were found to significantly determined intensity of adoption of improved maize varieties. Therefore, the results of this study suggested that strengthening the extension services, improvements in improved seed delivery systems to large scaling up, improving market access and arranging the way to create job opportunities for rural youth unemployment to participate in seed production business are important.
Keywords: Adoption, intensity of adoption, improved maize varieties, Hurdle Econometric Model, East Hararghe
DOI: 10.7176/JBAH/12-23-05
Publication date: December 31st 2022

1. Introduction

Maize is a widely grown food and cash crop that can be found within a broad range of environments a cross Sub-Saharan Africa. In Ethiopia, maize is currently produced by more farmers than any other crop (Chamberlin and Schmitd, 2012) and its total cropping area is still expanding (Taffesse *et al.,* 2012). According to Agricultural sample survey 2016/17 provided by the Central Statistical Agency at national level there are 11 million maize producing households on a total of 2.1 million hectors of land under maize. Of the major cereal crops, maize ranks second to tef [*Eragrostis tef* (Zucc.)] in area and first in production. Over the last five years, the area under maize has increased by about 50% and production by 66%, with the national average productivity of maize increasing from 34.31 to 39.92 Qt/ha (CSA, 2018). However, the average productivity of maize is still low in drought prone areas. In Ethiopia, drought prone growing areas consist of approximately 40% of the maize growing area yet contribute only 20% of the total production. That is mainly because the adoption rate of improved maize seed is low and farmers continue using varieties, which are old and do not have drought tolerance traits (Bediru, 2013).

The seed for open pollinated variety of maize is produced by the Ethiopian Seed Enterprise only in limited volume whereas the seed for hybrid maize is produced by both the public and private sector. The demand for hybrid maize under Ethiopian agricultural production system is very variable due to the agro-ecological diversity with considerable dependence on weather conditions (Dawit *et al.,* 2008). In line with this Fedis Agricultural Research Center has been conducted the adaptation trial of lowland maize varieties for the last previous years. After adaptation trial these varieties have been widely promoted through on-farm demonstration and small pilot seed production by agricultural extension research team of the research center. Recently, districts offices of agriculture and NGOs are working on the further promotion (scaling up) of these maize varieties in the drought prone districts of the East Hararghe Zone. Although different organizations has been participating in promotion of these maize varieties seeds still there are low adoption of these maize varieties due to various factors. For instance, totally only 1173.1 and 1850.9 quintals of various maize varieties were distributed for the last five years both in Babile and Fedis districts respectively (FARC, 2015 unpublished). Generally, this indicates that still there is low use of improved maize seed varieties in the study areas.

Even though, several studies have been conducted so far related to maize technologies adoption in other parts of Ethiopia *e.g.* Abadi (2014); Bediru (2013*);* Yu *et al.,* (2011); Shiferaw and Tesfaye, (2005); Yishak and Punjabi, (2011); and Alene *et al.,* (2000). However, there was no study conducted on the lowland maize varieties adoption in the study areas. Thus, the understanding and analysis of the adoption of improved maize varieties using empirical research in the study areas was crucial. The output of study was provide information for planners and policy makers for further promotion of important improved maize varieties in the study areas by identifying the most important factors that influence the adoption of improved maize varieties.

2. Methodology

2.1. Description of the study areas

This study was conducted in Babile and Fedis districts of East Hararghe Zone, Oromia Regional State, Ethiopia. Babile district is located (9° 13′ 09′′ N latitude and 42° 19′ 25′′ E longitude; 1642 m above sea level) and Fedis is located (9°07′N Latitude and 42°4′E Longitude; 1702 meters above sea level) (Figure 1). Babile district is situated some 35 km away from Harar and about 555 km east of Addis Ababa. The district has a total area of 3,169.06 km^2. It has a predominantly well drained sandy loam soil that is ideal for groundnut production. The rainfall distribution of the area is bimodal, with the main rain (locally referred to as Meher rain) received during July to October and short rain (locally known as Belg rain) during March to May. The mean annual maximum and minimum temperatures are 28.1°C and 15.5°C, respectively, with the total annual rainfall ranging from 507 to 984mm. Rainfall distribution at Fedis is also bimodal. Fedis has a total area of 1,105.02 km^2. The mean annual maximum and minimum temperatures in Fedis are 27.8°C and 8.8°C, respectively, with a total annual rainfall of 659.2 mm.

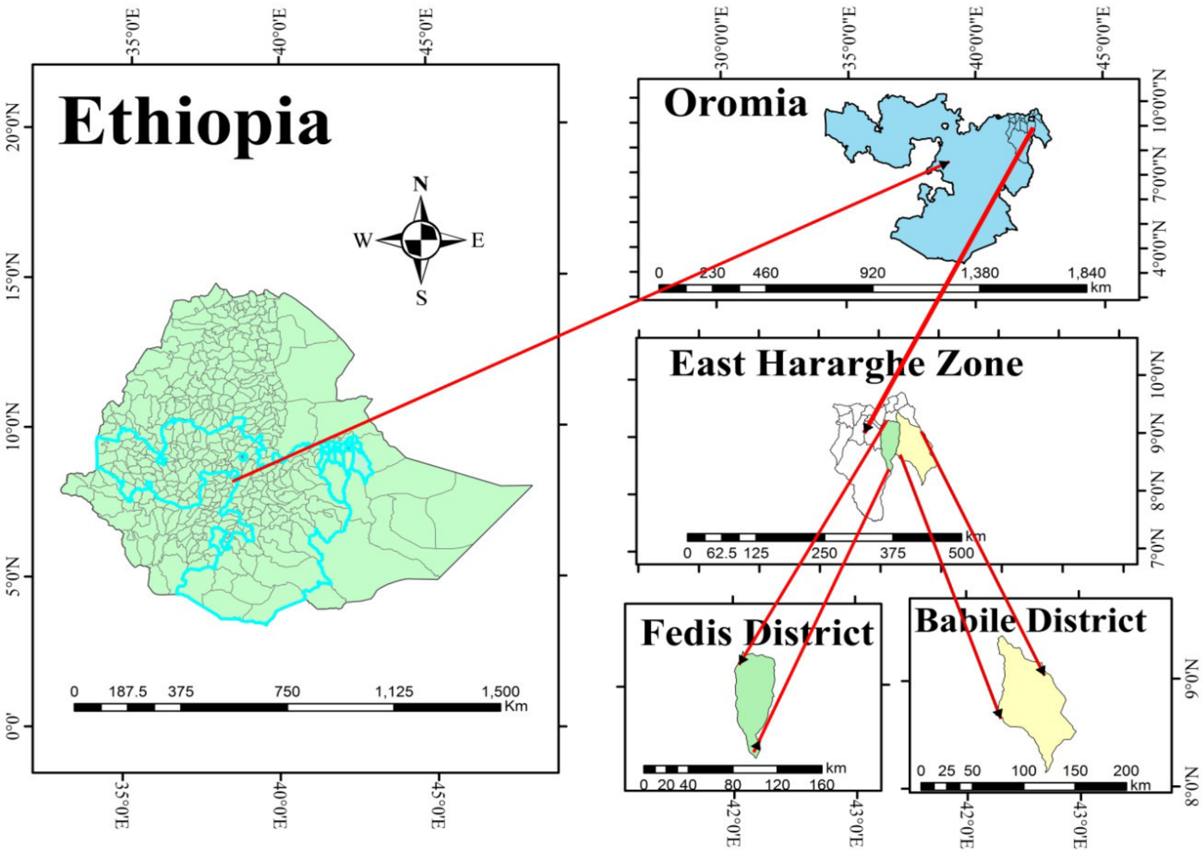

Figure 1. Map of the Study Areas

2.2. Sources of data and Methods of data collection

The study was used both primary and secondary data. Primary data was collected from sampled household heads interviews who were randomly selected from the selected kebeles using structured and semi-structured questionnaire. Secondary data was gathered from secondary sources (published and unpublished materials), Districts Office of Agriculture and Natural Resource Development and other sources.

2.3. Sampling procedure and sample size

A multi-stage sampling technique was used to draw sample households in the study areas. In the first stage Babile and Fedis districts were selected purposely based on their improved maize research intervention and promotion sites of Fedis Agricultural Research Center (FARC). In the second stage, three intervention *kebeles* were also purposively selected from each district. In the third stage, stratified random sampling was used to categorize maize producer farmers into adopter and non-adopters of improved maize varieties in each of the *kebel*e. Finally, simple random selection of household heads in each of two categories was employed based on proportional to population size.

2.4. Method of data analysis

Both descriptive and econometric analysis methods were used. Descriptive statistics were used for analyzing of level of adoption of improved maize varieties while Double-hurdle econometric model was used to analyze determinants of adoption and intensity of adoption of improved maize varieties in the study areas.

2.4.1. Model specification for Double-hurdle Model

The D-H model is a parametric generalization of the Tobit model, in which two separate stochastic processes determine the decision to adopt and the intensity of use of technology (Hailemariam et al., 2006). The first equation in the D-H model relates to the decision to adopt (y) can be expressed as follows:

$$\boldsymbol{y_i = 1 \ \ if \ y_i^* > 0 \ and \ 0 \ if \ y_i^* \leq 0} \quad (1)$$

$$\boldsymbol{y_i^*} = \boldsymbol{x_i'}\alpha + \boldsymbol{\varepsilon_i} \quad \text{(Adoption equation)} \quad (2)$$

Where:

$\boldsymbol{y_i^*}$ is latent adoption variable that takes the value of 1 if a household grew improved maize variety and 0 otherwise, x is a vector of household characteristics and α is a vector of parameters. Equation (1) is a probit model that examines the probability that the i^{th} farmer would make a decision to adopt improved maize varieties. The level of adoption (Z) has an equation as in the following:

$$\boldsymbol{z_i} = \boldsymbol{z_i^*} > 0 \ \text{ if } \boldsymbol{y_i^* > 0} \quad (3)$$

$$\boldsymbol{z_i^*} = \boldsymbol{z_i \beta + ui} \ \text{ and } \boldsymbol{y_i^*} = \boldsymbol{x_i'}\alpha + \boldsymbol{\varepsilon_i}, \boldsymbol{z_i = 0} \ \text{ otherwise} \quad (4)$$

$$\boldsymbol{z_i^*} = \boldsymbol{z_i \beta + ui} \quad \text{(Level or intensity of adoption)} \quad (5)$$

Where: $\boldsymbol{z_i^*}$ is the observed response on how much land one allocated to improved maize varieties, $\boldsymbol{z_i}$ is a vector of the household characteristics and β is a vector of parameters (Mignouna et al., 2011). $\boldsymbol{\varepsilon_i}$ and $\boldsymbol{ui}$ are the error terms. Where, $\boldsymbol{\varepsilon_i} \sim N(0, 1)$ and $\boldsymbol{ui} \sim N(0, \sigma^2)$. Following Cragg (1971) model, the study assumes independence between the two error terms.

The double hurdle model of Equation (2) (that is, the first hurdle) is a probit model that examines the probability that the ith farmer would make a decision to adopt improved maize varieties. Equation (4) (that is, the second hurdle) is a truncated regression model that examines the intensity of use improved maize varieties. Therefore, the log-likelihood of the DH model is the sum of the log-likelihood from a probit model and the truncated regression model.

3. Results and Discussion

3.1. Households' Demographic and Socio-economic Characteristics

Table 1 and 2 show the summary results of the descriptive statistics of the socio-economic characteristics of sampled farm households. The descriptive statistics results showed that the mean age of sample households was 36.22 years with standard deviation of 11.03. On average adopter household heads have 35.96 years while that of non-adopters of improved maize varieties have 37.35 years (Table 1). Average family size of the all-sample farm households was 6.89 members. On average adopter household heads have 7.22 members while that of non-adopter of improved maize varieties have 6.49 family members. The mean difference between the two groups was statistically significant at 5% significance level (Table 1).

Table 1. Households' demographic and socio-economic characteristics (Continuous Variables)

Variables	All sample (N= 218)		Adopter(N=142)		Non-Adopter (N=76)		T-Value
	Mean	SD	Mean	SD	Mean	SD	
Age of household head	36.22	11.03	35.96	10.35	37.35	12.27	0.45
Family size	6.89	2.84	7.22	2.80	6.49	2.76	2.30**
Total land holding in ha	0.88	0.58	0.97	0.59	0.71	0.49	3.36***
Total livestock (TLU)	2.49	2.29	2.74	2.57	2.18	1.88	1.38*

Variables	All sample (N= 218)		Adopter(N=142)		Non-Adopter (N=76)		T-Value
	Mean	SD	Mean	SD	Mean	SD	
Farming experience (years)	18.51	10.11	19.08	9.16	17.49	11.63	1.01
Distance to market (Minutes)	72.25	39.55	77.20	41.41	63.03	34.24	2.81***
Farm income (Birr/year)	32721	15205	38925	16490	24517	13920	5.48***

As to sex of household heads, out of the total 218 farm households, about 77% were male and the rest 23 were female headed farmers (Table 2). Based on sex of respondents, male adopters of improved maize varieties in the area is account for about 82% of the total adopter of improved maize varieties and female adopter accounts for 18% while out of 76 non-adopters of improved maize varieties, 68% of non-adopters are male and 32% of non-adopters are female. The result of chi-square analysis revealed that there is significant relationship between sex and the adoption of improved maize varieties at 1 % significant level.

Regarding access to extension services, the result indicated that out of total sampled farm households, about 76% have access to extension services and 24% of total sampled households have no access to extension services on maize production (Table 3). As shown in table 2, about 85% of adopters and 41% of non-adopters have access to extension services on maize production in the study area. This implies that in a larger proportion of sampled farm households have accesses to extension services while smaller proportions have no access to extension services. The chi-square result shows statistically significant difference at less than 1% significance level between adopters and non-adopters with respect to farmers' access to extension services. As to access to credit services the survey result indicated that out of the total sampled farm households, about 72% of sampled households did not borrow any credit to finance their agriculture production activities.

Table 2. Households' socio-economic characteristics (Categorical Variables)

Variables		All sample (N= 218)		Adopter (N=142)		N-Adopter (N=76)		Chi square test
		Freq.	%	Freq.	%	Freq.	%	
Education level	Illiterate	106	49	61	43	45	59	16.82*
	Read and write	19	9	10	7	9	11	
	Informal/religious	17	7	13	9	4	5.26	
	Literate	76	35	58	41	18	25	
Marital status	Married	209	95.87	136	95	73	96	2.36**
	Single	3	1.38	1	0.7	2	2.63	
	Widowed	5	2.29	4	2.82	1	1.32	
	Divorced	1	0.46	1	0.7	0	0	
Sex	Male	168	77	116	82	52	68	5.96***
	Female	49	23	25	18	24	32	
Membership to cooperatives	Yes	75	34	61	43	14	18.4	12.79***
	No	143	66	81	57	62	81.6	
Participation in off farm activities	Yes	72	33	54	38	18	24	4.09**
	No	146	67	88	62	58	76	
Access to extension services	Yes	165	76	120	85	45	41	15.14***
	No	53	24	22	15	31	39	
Access to credit services	Yes	61	28	47	34	14	18	5.89***
	No	157	72	95	66	62	82	

Source: Survey result, 2021/22, ***, ** and * indicates significance level at 1%, 5% & 10%, respectively

3.2. Adoption level of improved maize varieties

The adoption level on the improved maize varieties is presented in the Table 3. Analysis of level of adoption of improved maize varieties indicates that of the total sampled households, 65.14% were adopters and whereas, 34.86% were non-adopter farmers to improved maize varieties in the study areas. There are four levels of adoption categories of improved maize production in the study areas. Adoption categories were determined by the proportion of land which was allocated for the production of maize in the study area. These are non-adopter, low adopter, medium adopter and high adopter of improved maize varieties in the study area. Non-adopters were

34.86% from total respondents and zero percent covered by improved maize varieties. Low adopters were 5.50% of the total sampled households and less than 50% of farm land covered by improved maize varieties during 2020/1 cropping season.

Table 3. Adoption intensity of improved maize varieties by the households in the study areas

Adopter category	adoption level	Frequency	Percentage
Non-adopters	0	76	34.86
Low adopters	<50%	12	5.50
Medium adopters	51-69%	18	8.26
High adopters	70-100%	112	51.38
Total		218	100.00

Source: Own survey result, 2021/22

3.3.1. Factors affecting adoption of improved maize varieties

The factors affecting adoption of improved maize varieties were estimated using probit regression model (first hurdle). The model result from Table 4 indicated that from fourteen variables included in the model eight were found to be significantly affecting the adoption of improved maize varieties at different probability levels. Details of significant variables from this model were discussed as follows.

The results revealed that the age of the household head significantly and negatively influenced the probability of improved maize varieties adoption. This result shows that older farmers are less likely to adopt improved maize varieties. Possibly, young farmers are more flexible, more often exposed to new ideas and more likely to bear risk than their older counterparts. The result is consistent with (Asfaw et al., (2012); Kassie et al., (2011) and Langyintuo and Mungoma (2008)).

Level of Education of the head of the household has a positive and significant influence on the adoption of improved maize varieties with each additional year of schooling increasing the probability of adoption improved maize varieties by 0.38 percent. Like previous studies (Ghimire *and Huang, 2016;* Alena and Rashid, 2000*).*

The farming experience was also positive and significant at 10% level of probability to adopt improved maize varieties by 0.93 percent. This implies that as the farmers acquire more experience in maize production of as the adoption of new varieties increases. It is also expected that experienced farmers may be able to understand the nature of risk associated with each of the technologies, having practiced or seen some of them used over time. The finding is also in line with the study (Kindu et al., 2011; Endrias, 2003).

Distance to the main market was found to be negatively significantly correlated with the likelihood of adoption. Each additional minute of walking was associated with 0.16% less probability of adoption when other variables were kept constant. This indicates that farmers living at a distance from the main market centers are less likely to adopt the improved maize varieties than those who are located closer. The implication is that the longer the distance between farmers' residence and the market center, the lower will be the probability of improved maize varieties adoption. This may be due to relatively proximity to market also reduces marketing costs. This result is consistent with other studies (Abadi, (2014); Kebede (2006); Tesfaye *et al*. (2001)).

Table 4. Estimation results of first hurdle (probit) econometric model

Variables	**Coefficient**	**Marginal effects**	**Robust Std. Err.**	**P- value**
Sex of household head	0.2164	0.0548	0.3475	0.534
Age of household head	-0.0003**	-0.00006	0.0002	0.042
Education level of household head	0.0161**	0.0038	0.0710	0.036
Family size of household head	0.0134	0.0031	0.0606	0.826
Farmer Experiences	0.0391*	0.00928	0.0225	0.083
Distance to market	-0.0067**	-0.0016	-0.0033	0.042
Cooperative membership	0.3429	0.0771	0.3226	0.288
Landholding	0.5364*	0.1276	0.2831	0.058
Off-farm activities	0.1333	0.0309	0.2734	0.626
Access to Credit services	0.0320	0.0075	0.3278	0.922
Access to extension services	0.8769***	0.2596	0.3161	0.000
Livestock owned (TLU)	0.0058	0.0013	0.0559	0.917
Access to improved seeds	0.5443***	0.1294	0.1165	0.000
Districts dummy	0.7834**	0.1766	0.3301	0.018
_Cons	-3.003***	-	0.6063	0.000

Source: Own field survey data (2021/22), Number of observations: 218; Log-likelihood: – 108.846; LR chi2 (14): 57.31; Prob > chi2: 0.0000; Pseudo R^2: 0.4965; ***, ** and * indicate significant parameters at 1 per cent, 5 per cent and 10 per cent levels, respectively.

Landholding was found to be positively related with the adoption of improved maize varieties at less than

10% probability level. The positive and significant coefficient indicates that as cultivated land area increases by one unit, the likelihood of adopting improved maize varieties also increases by almost 12.76 per cent, confirming the expectation that owning more farmland is correlated with higher adoption rates. Consistent with earlier findings (Kassie et al., 2011; Mariano et al., 2012; Mendola, 2007), the result likely reflects the importance of land area among rural farming households for the cultivation of new-generation crop varieties.

As expected access to extension services had a positive and significant effect on the probability of adoption of improved maize varieties at less than 5% significance level. Other variables held constant, for each additional contact with extension agents the probability of adoption of improved maize varieties increases by 87.69 percent. The result indicated higher probability of farmers with more contact with extension agents in adopting than farmers with less contact. The possible justification for this is that frequent contacts create awareness and build the necessary knowledge for using the innovation and enhancing the exposure of farmers on the adoption practice of improved technologies. This is in line with the previous studies (Getachew *et al.,* 2009; Susie and Bosena, 2020).

As expected access to improved maize seeds was positively and significantly determined adoption of improved maize in the study areas at less than 1% significance level. Provision of improved maize seed to farmers in the required quantity and at the right time increases the probability of adoption of the seed by 12.94 percent. The finding is also in line with the study (Ghimire *and Huang, 2016;* Getachew et al., 2009; Alene and Rashid, 2000).

The district dummy variable was found to have a positively significant impact on adoption of improved maize varieties at less than 5% significance level. This implies relative to farmers in Fedis (the reference group), farmers in Babile district are more likely to adopt improved maize varieties. This implies that being the Babile district increases the probability to the adoption of improved maize varieties by 17.66 percent. This is due the fact that agro-ecologies differences, distance to the research center, distance to access to market infrastructure, existence of Non-government organization that are working on the seed multiplication and related to seed business (e.g. Integrated Seed Sector Development Project).

4.3.2. Determinants of intensity adoption of improved maize varieties

The factors affecting the intensity of use of improved maize varieties were estimated using truncated regression model. The model result from Table 5 indicated that from fourteen variables included in the model seven were found to be significantly affecting the intensity of use of improved maize varieties at different probability levels. Details of significant variables from this model are discussed as follows.

The sex of household head was influence the use intensity of improved maize varieties positively and significantly at less than 5 percent significance level. As compared to female headed households, the intensity of use of improved maize varieties for male headed household increased by 6.88 percent. The result suggests that those male headed households are more likely to allocate larger amount of land to improved maize varieties than female headed. This is because male household head are better to access to land and information about improved technologies. This is in line with the previous studies (Getachew *et al.,* 2009; Susie and Bosena, 2020).

Age had negative and significant influence on the intensity of use of improved maize varieties at 5% probability level. Other variables held constant, as age of the household increases by a year, the intensity of use of improved maize varieties decreases by 0.18 percent. This implies that the older the respondents the smaller land allocated to the improved maize varieties. This agrees with the previous studies (Susie and Bosena, 2020; Akinbade and Bamire, 2015).

Contrary to expected the family size was significant at 10% level of probability with negative coefficient which indicates that there is a negative relationship between family size and level of adoption of improved maize varieties. The larger family size the lower the level of adoption of improved maize varieties. If household size increases by one person, the area allocated to the variety decreases by 1.8 percent. This suggests that labor added through an increase in the number of household members is diverted to some sector other than improved maize cultivation. Particularly in the studies are most of the producers are included in the productive seftnet program (PSP). This agrees with the previous studies (Ghimire *and Huang, 2016;* Getachew *et al.,* 2009).

Table 5. Truncated regression estimates for the use intensity of improved maize varieties

Variables	**Coefficient**	**Robust Std. Err.**	**P- value**
Sex of household head	0.0688**	0.0647	0.028
Age of household head	-0.0018**	0.0025	0.047
Education level of household head	0.00055	0.0116	0.962
Family size of household head	-0.0179*	0.0105	0.087
Farmer Experiences	0.0065*	0.0036	0.073
Distance to market	0.00042	0.0004	0.379

Variables	Coefficient	Robust Std. Err.	P- value
Cooperative membership	-0.0199	0.0526	0.704
Land holding	0.15942***	0.0473	0.001
Off-farm activities	-0.00947	0.0482	0.844
Access to Credit services	-0.07522	0.0589	0.202
Access to extension services	0.02617	0.0750	0.727
Livestock owned (TLU)	-0.0052	0.0055	0.346
Access to improved seeds	0.3294	0.0251	0.149
Districts dummy	0.03621***	0.0752	0.000
_Cons	-0.13439	0.1519	0.376
/sigma	0.22930***	0.0307	0.000

Source: Own field survey data (2021/22); ***, ** and * indicate significant parameters at 1 per cent, 5 per cent and 10 per cent levels, respectively

The farm size influence the use intensity of improved maize varieties positively and significant at less than 1 percent significance level. As the land size increases by one hector, the intensity of land allocated to improved maize varieties increases by 15.94 percent. As expected, the larger the farm size, the more the areas planted with improved maize varieties. This agrees with the previous studies (Susie and Bosena, 2020; Akinbade and Bamire, 2015; Alene and Rashid, 2000).

The effect of district variable on the intensity of use improved maize varieties was found positive and significant at less than 1%. Being Babile District, increases the land allocated to improved maize varieties by 3.62 percent. This implies farmers in Babile District devote more of their maize land to improved maize varieties. Babile District is high moisture area, this may cause farmers to use more improved maize varieties than local varieties to adapt and get more maize production. In addition Babile District has access to more land than Fedis District.

5. Conclusion and Recommendations

5.1. Conclusion

Increasing agricultural productivity and improving the sustainable livelihoods of rural farmers are among the government policy priorities. In this effort, adoption of improved agricultural technologies is expected to play a vital role. The study was aimed to identify determinants of adoption and intensity of adoption of improved maize varieties in the Babile and Fedis districts, East Hararghe Zone, Oromia Regional State, Ethiopia. A double-hurdle econometric model was employed. The study empirically provides that farmers' decision to adopt and the level of area proportion to allocate to improved maize varieties were made separately.

The model estimate results showed that age of household head, level of education of household head, farm experience in maize production, total farm size owned, access to extension services, improved maize seed availability, the distance nearest market and districts dummy significantly determined the adoption of improved maize varieties in the first hurdle model (probit). In the second hurdle (truncated), sex of household head, age of household head, family size, farm experience, total farm size owned, districts dummy were found to be significantly determined intensity of adoption of improved maize varieties in the study areas. Overall, the adoption of improved maize varieties in the study areas was determined by socio-economics and institutional factors. On the other hand, the intensity of adoption of improved maize varieties in the study areas was determined by socio-economics factors.

5.2. Recommendations

The fact that extension services are making a difference; it follows that policy makers need to focus on targeting resource poor farmers who represent the farming communities in the study areas. At the same time, availability of improved seed proved to be a major constraint for adoption, a fact that calls for improvements in improved seed delivery to effectively cope with the demands of small farmers. Improving the existing market center in the study areas through construction of whether roads and providing good transport facilities for farmers need to be given more attention to enhance the adoption of improved maize varieties.

Moreover, enhancing farmers' resource endowment in terms of labor and land allocated also enhance the probability and intensity of maize variety adoption by smallholder farmers. Encouraging youth in improved seed production and allocating uncultivated land to improved maize varieties are suggested to policy makers.

6. References

Abadi T. 2014. Impact of improved maize varieties adoption on smallholder Farmers' marketed maize surplus in Oromia regional state, Ethiopia
Abdi B. 2013. Access to Seed and Variety Adoption of Farmers in Ethiopia: A Case of Open Pollinated Maize

in Drought-Prone Central Rift Valley.

Akinbode O. W. and Bamire, S. A. 2015. Determinants of adoption of improved maize varieties in Osun State, Nigeria. Department of Agricultural Economics, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria. Journal of Agricultural Extension and Rural Development. 7(3):65-72.

Alene, A., Poonyth, D. and Hassan, R. 2000. Determinants of adoption and intensity of use of improved maize varieties in the Central Highlands of Ethiopia: A Tobit Analysis. *Aggreko* 39(4): 633-643.

Asfaw, S., Shiferaw, B., Simtowe, F., & Lipper, L. 2012. Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. *Food Policy, 37*(3), 283–295. doi:10.1016/j.foodpol.2012.02.013

Chamberlin. J. and E. Schmidt. 2012. Ethiopian agriculture: a dynamic geographic perspective. In P. Dorosh and S. Rashid, ed. *Food and Agriculture in Ethiopia: Progress and Policy Challenges*. Philadelphia PA: University of Pennsylvania Press.

Central Statistical Agency (CSA). 2018. Area allocated under crop production in Ethiopia.

Cragg J. 1971. Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods. Econometric, 39(5):829-844.http://dx.doi.org/10.2307/1909582.

Endirias G. 2003. Adoption of improved sweet potato varieties in Boloso Sore woreda, Southern Ethiopia. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Getachew L, Langyintuo A. Moti J and La Rovere R. 2009. Household resource endowments and determinants of adoption of drought tolerant maize varieties: A Double-Hurdle Approach, 2009 conference, August 16-22, 2009, Beijing, China, International Association of Agricultural Economics.

Ghimire and Huang. 2016. Adoption Pattern and Welfare Impact of Agricultural Technology: Empirical Evidence from Rice Farmers in Nepal. *Journal of South Asian Development 11(1).*

Gujarati. 2004. Basic Econometrics, Fourth Edition. The McGraw-Hill Companies, Hailemariam T, Dadi L, Yami A, Dana N (2006). Determinants of adoption of technology: a double-hudle approach." Livestock Research for Rural Development (International Livestock Research Institute) 18:3

Kassie, M., Shiferaw, B., & Muricho, G. 2011. Agricultural technology, crop income, and poverty alleviation in Uganda. *World Development, 39*(10), 1784–1795. doi:10.1016/j.worlddev.2011.04.023

Kebede, M. 2006. Farmers' Perception and determinants of land management practices in Ofla Woreda, Southern Tigray, Ethiopia. Dissertation for Award of MSc Degree at Haramaya University. Haramaya, Ethiopia. 98pp.

Langyintuo, A. S., & Mungoma, C. 2008. The effect of household wealth on the adoption of improved maize varieties in Zambia. *Food Policy, 33*(6), 550–559. doi:10.1016/j.foodpol.2008.04.002

Mariano M J, Villano R, Fleming E. 2012. Factors influencing farmers' adoption of modern rice technologies and good management practices in the Philippines. *Agric System*, **110**: 41–53.

Mignouna DB, Manyong VM, Mutabazi KDS, Senkondo EM. 2011. Determinants of adopting imazapyr-resistant maize for Striga control in Western Kenya A double hurdle Approach, J. Develop. Agric. Econ... 3(11) (Acad. J). 3(11):572-580.

Mendola M. 2007. Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh. *Food Policy*, **32**(3): 372–393.

Shiferaw, F. and Tesfaye, Z. 2005. Adoption of improved maize varieties in Southern Ethiopia: Factors and strategy options. *Food Policy* 31: 442–457.

Susie Teshome and Bosena Tegegne. 2020. Determinants of Adoption of Improved *Teff* Varieties by Smallholder Farmers: The Case of Kobo District, North Wollo Zone, Amhara Region, Ethiopia. *International Journal of Agricultural Economics*. Vol. 5, No. 4, 2020, pp. 114-122. doi: 10.11648/j.ijae.20200504.14

Taffesse, A.S., Dorosh P. & Asrat, S. 2012. Crop production in Ethiopia: regional patterns and trends. *ESSP Working Paper 16*. Washington, DC, International Food Policy Research Institute (IFPRI) and Addis Ababa, Ethiopia, Ethiopian Development Research Institute (EDRI).

Tesfaye Zegeye and Shiferew Tesfaye, 2001. Determinants of adoption of maize technologies and inorganic fertilizer in Southern Ethiopia. Research Report No. 39. Ethiopia Agricultural Research Organization (EARO). 54p.

Yishak, G. and Punjabi, N.K. 2011. Determinants of adoption of improved maize technology in Damot Gale, Wolaita, Ethiopia. *Raj. J. Extn. Edu.* 19: 1-9.

Yu, B., Alejandro N., Jose, F. and Asrat, G. 2011. Cereal Production and Technology Adoption in Ethiopia. ESSP II Working Paper 31.