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Original Research

Analysis of Adoption Spell of Hybrid Maize in the Central Rift Valley, Oromyia National Regional State of Ethiopia: A Duration Model Approach

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Abstract

This paper estimates farm household level determinants of the speed of adoption of hybrid maize in the central rift valley of Ethiopia in the framework of the dynamic time on cross-sectional data. Descriptive statistics and duration model were used to study the objectives of the study. The results from descriptive analysis showed that 85% of the farmers adopted hybrid maize at the survey time and more than 50% of the adopters started adopting hybrid maize within two years after they became aware of the varieties and the remaining started adopting afterwards but at a decreasing rate. The adoption pattern of farmers has also differed by gender and location. Duration model estimation results revealed that factors that influenced timing of hybrid maize adoption varied by the type of influence. Whereas house hold size, access to extension services and maize market participation accelerated the adoption of hybrid maize at increasing rate, age of household head and livestock ownership retarded the adoption. Operated land and unit price of seed worked towards accelerated adoption but at diminishing rate. Thus to speed up adoption of hybrid maize policies may need to give primary focus to the different categories of adopters, providing adequate extension information and reorienting the mindset of the farmers towards market orientation and household labor efficiency. Also, policies should identify particular roles of the different determinant factors and target the associating socio-economic setup of the smallholders.

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INTRODUCTION

Coping with increased population and running a profitable venture are major problems in developing countries of which Ethiopia is one. In Ethiopia, agriculture is leading sector in meeting these big concerns and maize is one of the most important crops in the country. Annually an estimated amount of over 6 million tons of maize is produced and 75% of it is consumed by the farming households whereas the balance is supplementing the diets of most of the urban poor. Also, Ethiopian maize, being non-GMO, has big demand sink among maize consuming countries of the world.

The production of maize has shown an increasing trend due to both land area and productivity, mainly in response to the local demand. Despite the annual gains in production there remains a large potential to increase productivity of the crop. Research results indicate that the current average yield level of 30qt/ha (CSA, 2013) could be more than doubled through use of improved maize technologies. A number of hybrids and open-pollinated varieties (OPVs) have been developed and disseminated for boosting production under different environments (Hadji, *et al*., 2001; Variety register, 2012). There are observations that hybrids are gaining popularity under moisture stressed environment and production of maize hybrid varieties have significant yield and profit advantages over the local and OPVs. However, the spread and contributions of these technologies along with proper management practices has not been moving as required. The uptake of hybrid maize has been limited and slow because of the lack of information and of sustainable access to the seeds, *ceteris paribus*.

Suwantaradol (2001) has found out that the lower price of maize grain and higher price of hybrid seeds resulted infarmers' hesitation to adopt the new varieties in Thailand. The information base on the reasons associated with technology adoption is incomplete under Ethiopian condition. To date only few technology adoption studies in Ethiopia(such as, Legesse, 2001; Dadi *et al*., 2004)have attempted the dynamic aspect of adoption in general whereas others (such as Getahun *et al*., 2000; Yishak and Punjabi, 2011) addressed factors influencing the probability of adoption in a static frame work.To the authors knowledge there are no or meagre studies in Ethiopia on hybrid maize adoption, particularly, in terms of analyzing the dynamic side (timing) of adoption; i.e., the effect of factors on the duration farmers waited before they first adopted the hybrid varieties. Therefore, the main objective of this study is to indicate the adoption pattern of hybrid maize in the mid-altitude moisture-stress areas of Ethiopia and also apply the duration model to determine factors affecting the timing of hybrid maize adoption. The results would contribute to informed decision making and designing appropriate agricultural policies for speedy technology dissemination in the study and similar areas.

MATERIALS AND METHODS

Sampling

This paper depends on the baseline survey data made with farm households during 2010/11 in the central rift valley area of Ethiopia where rainfall is erratic and drought has been one of the most important factors threatening agricultural production. Multi-stage sampling procedure was followed to identify sample farm-households. First, three districts; namely, Shalla, Adamitulu-Jido-Kombolcha and Dugda, were selected based on the distribution of maize production in the central rift valley area. Then three peasant associations were selected randomly from each district from a list of maize producing peasant associations. Finally 267 farm-households were randomly sampled after the sample size in each peasant association was determined based on probability proportional to size of maize producing households. Semi-structured questionnaire involving farmer, farm and institutional characteristics was administered to solicit primary data from the sampled farmers through trained enumerators.

Theoretical Setup of the Analytical Model

Household models of microeconomic theory (Neo-Classical) mostly take the household as having a single utility function (Ellis, 1993). A single household utility function assumes that the household contains one set of preferences and that the household is a unitary entity. While utility is not directly observed, the actions of economic agents are observed through the choices they make.

Considering that each smallholder household (i.e. the economic agent) under this study has two alternative outcomes; i.e., to adopt a given technology, denoted by "*A*" or not to adopt (to remain with the existing production practice) denoted by "*N*", in the attempt to maximize utility (*U*), the probability (*Pr*) that either of them is chosen can be given by:

$$Pr\ (AN) = Pr\ [U_{AN} = max\ (U_A, U_N)] \quad (1)$$

Hence, the probability of each state being selected depends on the maximum position it may receive from its competitor case. Therefore, the probability that each household will choose between the two alternatives can be given by:

$$Pr\ (A>0) = Pr\ (U_A > U_N) \quad (2)$$

or

$$Pr\ (N>0) = Pr\ (U_N > U_A) \quad (3)$$

It is implicit that the decision to adopt is influenced by farmer (*H*) and none-farmer (*nH*) specific characteristics (Pannell et al., 2006). Thus, the utility that each farm household is associating either of the choices (*AN*) with decision-influencing factors can be given as:

$$U_{AN} = f(H, nH) + e \quad (4)$$

Where, *e* is the error term.

Probability theory plays a fundamental role in duration analysis, because one can consider the probability of the end of the range instead of its length.

To this effect, the probability that a farmer will adopt a particular technology in period *t+dt*, given that he/she had not adopted until *t,* can be defined by hazard function as follows:

Let *f(t)* be the density function of T (the stochastic component); where, *t* is the end of the range. Its corresponding cumulative function (the CDF of *f(t)*) will be defined as the probability of an event occurring before or at time t:

$$F(t) = \int_0^t f(s)ds = Pr(T \le t) \quad (5)$$

Likewise, the distribution of T can be expressed by the survival function, *S(t)*, the reverse of the cumulative distribution function of T. This defines the probability of surviving until (not adopting in) time t, as:

$$S(t) = 1 - F(t) = Pr(T > t) \quad (6)$$

Thus the hazard function (rate), *h(t)*, defining the probability of an event (adopting the technology)at T=*t*, conditional on survival up to time *t* is:

$$h(t) = lim_{dt \to 0} \frac{P(t \le T < t+dt \mid T \ge t)}{dt} \quad (7)$$

$$= \lim_{dt \to 0} \frac{F(t+dt) - F(t)}{dt(1 - F(t))} = \frac{f(t)}{S(t)}$$

The hazard function is a sequence of conditional probabilities continuous over a time spell (in this case, conditional probability of adoption) with *F(t), S(t)* and *h(t)* being the different ways of expressing the distribution of T.

The Econometric Model

The present study employs duration model over farmers' technology adoption behavior. The model considers the expected time an individual spends in one state before transition to another, studying the difference in the time, T, between the two alternative and exclusive states (Lancaster, 1990). In the context of technological adoption, this transition lasts from the moment at which the technology is known about until its adoption is made effective. It is constructed as a behavioral model, in which the individual choices are modeled using cross-section data and incorporates dynamic elements to adoption.

In the present study into adoption of hybrid maize, the starting date has been set as the year in which the technology became known to the farmer. The exit date, or end of the spell, is the year the farmer adopted this technology. In specific cases, there are farmers that had not adopted the technology at the date of analysis, and the end of the time spell is thus unknown. Although adoption could take place in the future, for these cases, the statistical procedure is right-censored establishing the year when data were collected (2011/12) as the end date of the observation period.

Hazard-based duration models are ideally suited to modeling duration data. These models are useful in the case of duration dependent variables (Kiefer, 1988; Hensher and Mannering, 1994) such as number of years, number of days that are always positive (as against OLS assumption of the outcome variable to be normal). In addition, the models can handle time-varying covariates and censoring. The models have been conceptualized in agricultural technology adoption in early 2000's (Fuglie and Kascak, 2001).

Parametric, semi-parametric and non-parametric duration models have been used to study the duration for occurrence of an event in the context of event-associated influential factors (Aryasepehr *et al*., 2002). Parametric models are more efficient in their use of data because they do not reject what happens to covariates where adoptions occur. Functional forms that have been used for parametric duration models include the exponential, Weibull, Gompertz, logistic, lognormal and log logistic probability distribution (Cleves *et al*., 2004).

However, the two most commonly used parametric specifications in the duration models are the Weibull and the exponential distributions and this study takes advantage of these models reflecting different scenarios of the hazard function to evaluate the data and describe the duration of farmers' adoption response to hybrid maize variety information as related to farm and non-farm determinant factors.

The Weibull distribution is characterized by the hazard function,

$$h(t) = (\lambda p)\lambda t^{p-1} \quad (8)$$

With, $\lambda > 0, p > 0 and\ \lambda = e^{X\beta}$ If p>1.

The Weibull hazard equation can be further defined as:

$$h(t|X_j) = h_0(t)exp(X_j\beta_x = pt^{p-1}exp(\beta_0 + X_j\beta_x) \quad (9)$$

Where, β_0 and β_x are the parameters to be estimated and X_j are explanatory variables hypothesized to determine survival times. The function exhibits an monotonically increasing hazard rate with time when $p > 1$ while the hazard rate would be decreasing monotonically with time if $p < 1$. When, $p = 1$, it characterizes a constant hazard rate and collapses to the exponential distribution model.

The exponential distribution is characterized by a constant hazard function, h(t)=λ, where λ> 0 implying that the hazard function is duration-independent; i.e. the duration time (length of spells) does not affect the hazard rate (or that the conditional 'probability' of an event is constant over time).

The baseline hazard, $h_0(t)$, is given as:

$$h_0(t) = \lambda, \lambda = exp(\beta_0) \quad (10)$$

Given, determinant factors, the model can be defined by

$$h(t|X_j) = h_0(t)exp(X_j\beta_x) \quad (11)$$

$$h(t|X_j) = exp(\beta_0)exp(X_j\beta_x) \quad (12)$$

$$h(t|X_j) = exp(\beta_0 + X_j\beta_x) \quad (13)$$

Where, β_0 and β_x are the parameters to be estimated and X_j are explanatory variables hypothesized to determine survival times. The result of this model is the expected remaining time to adoption and is independent of prior survival times.

Therefore in defining the influence of farmer and none-farmer specific characteristics on the time to adoption of hybrid maize, the hazard function can be reformulated, as follows:

$$h(t, X, \theta, \beta) = h_0(t, \theta)exp(X, \beta)) \quad (14)$$

where, X is the vector of covariables independent of time, β the associated unknown parameter vector, and $h_0(t, \theta)$ the baseline hazard function independent of the variables X.

Once an appropriate parameterization is selected, the parameters are estimated through procedures of maximum likelihood considering the censored observations and assuming the duration for each individual is independent of the others. The two models are then evaluated using Akaike Information Criterion (AIC) for model selection following Amemiya (1985).

RESULTS AND DISCUSSIONS

Descriptive Analysis of Hypothesized Variables

Table 1 summarizes the socio-economic characteristics hypothesized to influence farmers' time to adoption of hybrid maize which could also be defined as farmers' innovation assessment lag. The table shows that among the 267 farmers about 15.7% are censored (or none-adopters) and the remaining (84.3%) are adopters of hybrid maize at the time of the survey. Male household heads constituted 86% of the sampled respondents. However, disaggregation of the data by adoption status shows that male farmers constituted 83% and 87% of none-adopters and adopters respectively. On average, the respondents have 41 years of experience in growing maize, only 3 years of formal education and 3 adult family members. They have about 2.2 hectares of cultivated land and about 6TLU.

The farmers apply about 130kg/ha of DAP and Urea fertilizer on maize. They sell about 68% of the maize produced. At the time of the survey, the average price of maize seed was 2.7Birr/kg(equivalent to 0.14USD/kg) whereas pure hybrid maize seed was sold for 6Birr/kg. This may exhibit that most of the farmers buy either cheaper seeds or obtain subsidized seeds either from the neighboring farmers or from the local market or none-profit making organizations (such as research institutions, non-governmental organizations).The most probable reason could be that there was lack of access to original hybrid maize seed and farmers' exposure to inferior quality seeds, the source of which could be the open market or farmer-to-farmer. An average farmer receives53% of the trainings organized on agricultural extension. Only 18% of the farmers have access to credit.

Table 1: Description and summary statistics of explanatory variables (n=267)

Covariates	Censored (n=42)		Adopters (n=225)		Total (n=267)	
	Mean	Std.	Mean	Std.	Mean	Std.
Sex of head (1=Male)	0.83	-	0.87	-	0.86	-
Age of household head	41.14	12.91	40.96	13.49	40.99	13.38
Education level of head	2.29	3.01	3.38	3.36	3.21	3.33
Household size (man-equiv.)	2.67	1.26	3.32	1.69	3.22	1.64
Land operated (ha)	1.91	1.38	2.29	1.59	2.23	1.57
Livestock (TLU)	4.09	3.17	6.26	4.58	5.92	4.45
Fertilizer use/intensity (kg)	43.61	72.05	145.86	184.78	129.77	175.91
Price of the seed/kg	2.85	0.60	2.74	0.64	2.76	0.63
Maize market participation (% sold)	0.38	0.49	0.74	0.44	0.68	0.47
Extension training index	0.47	0.26	0.54	0.24	0.53	0.24
Access to credit (1=Yes)	0.09	-	0.20	-	0.19	-

Econometric Analysis

The data set obtained from the respondents to assess the effect of hypothesized variables on the time to adoption of hybrid maize was checked for multicollinearity, heteroscedastisity and model specification. Two variables (operated land and input price) were transformed into their square root form. Variance inflation factor and correlation tests revealed that the variables there was no serious multicollinearity observed (VIF<5 and correlation coefficients <0.4, none-significant,on anyone of the independent variables). Robust estimation method was employed to correct for minor heteroscedasticity.

The hypothesized variables were estimated by the two (Weibull and Exponential) models and Akaike Information Criterion (AIC) test (Akaike, 1973) was used to select the model of best fit. Following the minimum AIC rule (Amemiya, 1985), the Weibull model registered lower AIC value (460.98) compared to the exponential model (552.12) suggesting a non-constant hazard rate type (Weibull) model to best explain the data on duration dependence. Post-estimation specification test (Pregibon, 1979) resulted in non-significant y-hat square at 1% level of statistical significance indicating the existence of no problem with specification of the selected model.

The non-parametric Kaplan_Meier estimator of the survival function (Figure 1) was used to describe the adoption-spell, which is the difference between the year of first hybrid maize awareness and the first year of hybrid maize variety adoption. It can also be used to understand the distribution of net-adopters over the specified length of time. The horizontal axis shows the number of years that elapsed from the year of awareness to the year of first adoption of hybrid maize and the vertical axis shows the respective probabilities. The curve shows more than 50% of the farmers adopted hybrid maize within two years from the year of first exposure and the rate of adoption dropped to 34% and decreased constantly afterwards. Figure on cumulative adoption (Figure 2) also shows the same trend; there was quick adoption during the first two years and the gain was small afterwards.

Figure 3 shows survival time for male and female respondents. The survival time of male farmers' is shown by the lower curve indicating that male farmers are more likely to adopt the hybrid technologies earlier (quicker) than female farmers. However, the trend indicates a closer relationship for late adopters (i.e. 6 years later).

Figure 4 explains Kaplan_Meier estimator of the survival function disaggregated by the three districts. Accordingly farmers' rate of adoption in the first two years after exposure to hybrid maize was 50% at Dugda, 60% at Adami Tulu and 75% at Shalla districts. Also as we can observe the performance of the individual lines in the first two years of maximum adoption, the graph gives usa general indication that farmers at Shalla are early adopters followed by those at Adami Tulu and Dugda.

Figure 5summarizes the adoption behavior of the farmers. The line explains that farmers began adopting the hybrid maize varieties two years after being exposed to the varieties, with the shape of the survival function between 3 and 6 years showing lower share of households that are adopting the hybrid and rose sharply after the drop which implies that if farmers did not adopt the new hybrid within two years of being exposed to it, then they are less likely to adopt it in the following short period (3 to 6 years) and they increase the adoption at faster rate during the latter years. The reason could be that farmers who are quick to learn and benefit from new technology adopt and test the technologies immediately after exposure to the technologies whereas their counterparts are skeptical about new technologies and wait a longer period of time to get convinced and once this happened they tend to adopt the technologies quickly (Fisher *et al*., 1996).

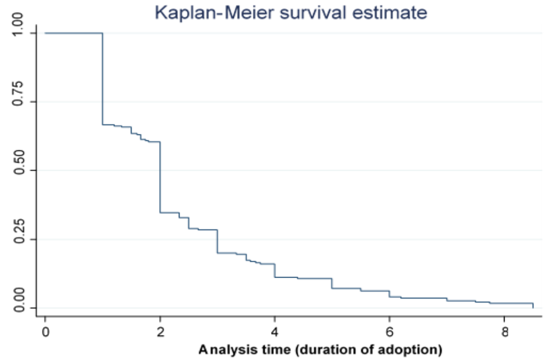

Figure 1: Kaplan-Meier survival estimate

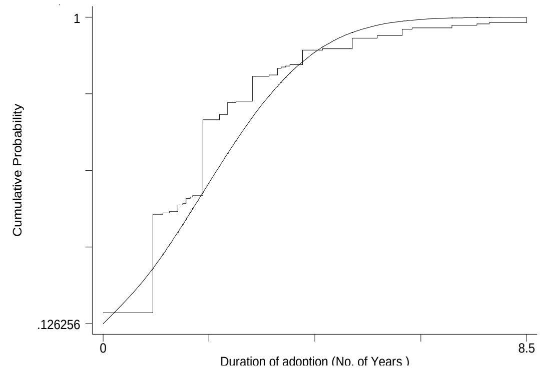

Figure 2: Cumulative adoption

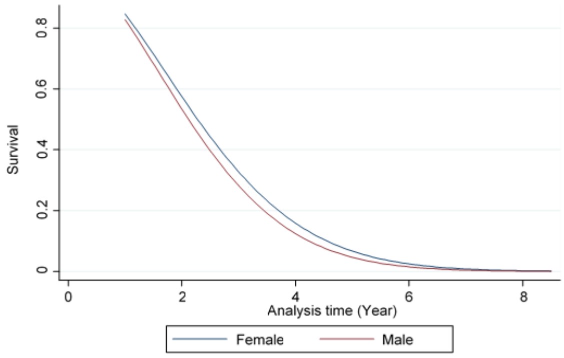

Figure 3: Survival time by gender of HHH

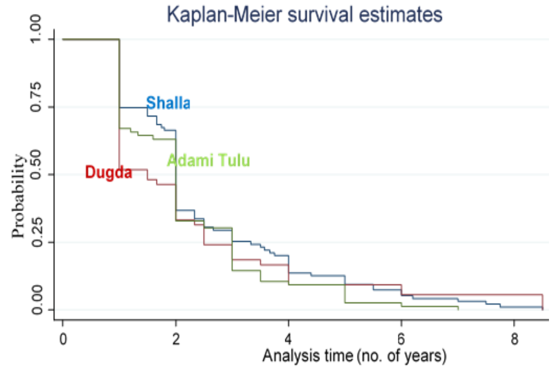

Figure 4: K-M survival estimate by district

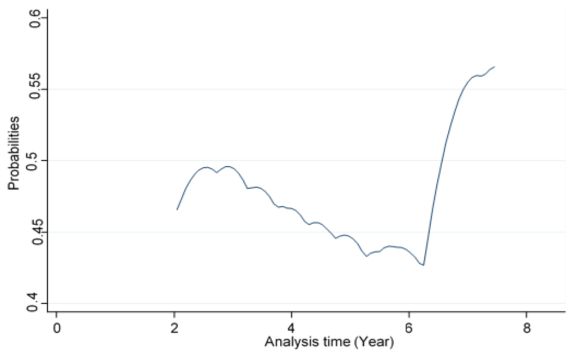

Figure 5: Smoothed hazard estimate

The adopted Weibull model was significant at 1% level (Table 2). The test of no duration dependence (ln P) is rejected at 1% level of statistical significance. The hazard ratio is also greater than one (i.e. it is 1.735) indicating a monotonically increasing hazard in time (i.e. with time, observations are showing failing trend at a faster rate or positive time dependence).Hazard ratios, as reported in Table 2, generally indicate the impact of covariates on adoption. Coefficients less than one show longer pre-adoption spell and lower probability of adoption. On the other hand, a value greater than unity is indicative of faster adoption.

Model output (Table 2) indicates that seven variables are associated better with the timing of adoption of hybrid maize among the sampled smallholder maize farmers as indicated by the level of their statistical significance. Thus, age of household head, household size, operated land, livestock, maize market participation, unit price of seed and access to extension services have significant impact on adoption by the respective hazard ratio of 0.982, 1.127, 1.605, 0.951, 1.391, 2.420 and 2.731. Among these, household size, access to extension services, operated land, maize market participation and unit price of seed speed up the probability of adopting hybrid maize and the remaining two factors stretch the pre-adoption spell of adopting hybrid maize. The magnitude of marginal effect tells us that extension information followed by price and operated land size are the leading determinant factors of hybrid maize adoption time.

Household size defined by the number of adults in a farm household is positively related with the speed of adoption of hybrid maize. The impact of household size is expected to be related to the availability of labor and their performance. The negative marginal effect (ME = -0.151) obtained on the variable implies that farmers with large household size were likely to take shorter time to adopt hybrid maize than those with less. The result corroborates with Croppenstedt *et al*. (2003) who argue that households with a larger pool of labor should be more likely to adopt agricultural technology and use it more intensively because they have fewer labor shortages at peak times. In so doing they play the role of increasing the speed of adoption.

Extension training facilitates early adoption since it is associated with access to information on improved technologies and productivity consequences. Yirga (2007) reported a strong positive relationship between access to information and the adoption behavior of farmers. Yishak and Punjabi (2011) also reported that participation in on-farm demonstration and attendance of training contributed positively to farmers' adoption decision. Studies elsewhere (Abdulai and Huffman, 2005; D'Emden *et al*., 2006) have also identified that farmers who have access to agricultural extension programs are more likely to adopt different technologies. Through training, farmers are able to understand the benefits of improved practices better than their counterparts. As expected, it would lead to shorter time to adoption, because of the role it plays in the creation of positive mental attitude that is necessary for the acceptance of new practices. This argument is also in agreement with Caswell *et al.* (2001).The marginal effect on the variable indicates that farmers who attended extension training programs quite often are likely to adopt hybrid maize faster. In other words, increase in the frequency of training would result in shorter time to adopt hybrid maize. The implication is that the speed of adoption is greatly influenced by the intensity of technical information received.

Availability of cultivable land allows farm households to try new technologies, given the size of land holding. The probable reason is that farmers with larger operated land size can afford the expenses on new agricultural technologies and also can bear the risk in case of failure of crop due to economies of scale. Studies on new technology adoption (Roy *et al*., 1999; Yishak and Punjabi, 2011) reported that farmers with large farm size are more likely to adopt improved maize varieties. Workneh and Michael (2002) also reported that operated farm size affects technology adoption positively. Others (Bradshaw *et al*., 2004) reported both negative and positive effects of farm size on the adoption of agricultural technologies showing that the effect of farm size on technology adoption is inconclusive. The negative marginal effects for operated land (ME = -0.601) implies that farmers who have better operated land area are able to take up the technology (hybrid maize) earlier compared to their counterparts. Therefore, availability of operated land contributes to shortening of the time to adoption.

Increased participation of the farmers in maize marketing is important for reducing the adoption lag. This is because increased participation serves both as a signal for market orientation of the farmers and a means of generating income. Household income increases the possibility of acquiring and/or adopting an innovation by mitigating the shortage of capital input while households with less or no income are likely to be highly risks averse. The negative marginal effect also shows that if farmers' participation increases the adoption spell for hybrid maize decreases.

Regarding the role of input prices, studies indicate that decrease in input price favors adoption speed (Marsh *et al*., 2000; Yishak and Punjabi, 2011). Contrary to expectations, in this study we found negative association between an increase in input price and adoption spell. Farmers tend to adopt hybrid maize seed rapidly irrespective of the increase in price. The implicit reason could be that price and quality go hand in hand particularly more strongly when the impact of technology disseminated on net return is visible among its recipients. However, there is a resultant decrease in the time to adoption embodied in the variable and this would imply that the effect is decreasing with diminishing returns (i.e. since the relation was established considering the square root transformed input price). In the study area farmers know the productivity gain they make from hybrid maize.

However, since supply of hybrid maize seed is very limited due to the limited activities of seed producers in the study area, we often observe unsatisfied demand. Therefore, inference can be made that introduction of technologies will be effective if farmers are convinced about the quality and efficacy of the particular technology to counteract the negative influence of price.

On the other hand increase in age of the household head would increase the time to adoption of hybrid maize since older farmers tend to be risk averse than younger farmers and as age increases the ability (tendency) to participate in input-intensive venture would decrease due to diminishing marginal utility of labor (due to aging/fatigue). Farmer's age and adoption of the given crop technology are inversely correlated. Old farmers usually tend to experience much with their traditional farming practices. According to Anderson et. al. (2005) older farmers are less likely to adopt technologies which is in support of the result of this study. The marginal effect on age also shows that as age increases the duration of adoption of hybrid maize increases confirming that the older farmers have less incentive to adopt this technology.

Livestock ownership (TLU) took an unexpected sign of marginal effect (ME = 0.064) implying that farmer with more number of livestock are likely to adopt hybrid maize slightly later than those with less. Similar result was also found by Murage *et al*. (2012) for late adoption of technologies among livestock owners. Herd size has a positive effect on the adoption duration probably because these resources could offer an alternative farm income source to hybrid maize and as livestock holdings increase farmers may forego (become reluctant) to become early adopters. Also livestock play a very important role by serving as a store of value and provision of manure required for soil fertility maintenance (Yirga, 2007) and this could guide farmers to waiver their adoption decisions for an extended period. The result is in contradiction with Habtemariam (2004) who reported positive relationship between livestock ownership and early adoption of agricultural technologies.

Table 2: Weibull model estimated coefficients for the adoption of hybrid maize varieties (n=225)

t	Haz. Ratio	Robust Std. Err.	ME	Std. Err
Sex of head (1=male)	1.134	0.246	-0.160	0.275
Age of household head	0.982	0.007**	0.022	0.010**
Education level of head	0.992	0.024	0.010	0.031
Household size (man-equiv.)	1.127	0.064**	-0.151	0.074**
Land operated (sqrt ha) ((square root)	1.605	0.352**	-0.601	0.283**
Livestock (TLU)	0.951	0.022**	0.064	0.029**
Fertilizer use/intensity (kg)	1.000	0.000	0.001	0.001
Maize market participation (%)	1.391	0.280*	-0.419	0.262*
Price of the seed/kg (square root)	2.420	0.799***	-1.123	0.416***
Extensiontraining	2.731	0.940***	-1.277	0.452***
Access to credit (1=yes)	0.776	0.156	0.322	0.260
_cons	0.018	0.014***	-	-
/ln_p	0.551	0.038		
P	1.735	0.065		
1/p	0.576	0.022		
Wald chi2(11)	34.05			
Prob> chi2	0.000			

CONCLUSIONS

Technology adoption is one of the means for increased food production and income generation among smallholder farmers. Descriptive analyses suggest that farmers' adoption behavior can be classified as early adopters, late adopters and none-adopters. The adoption status of farmers also varied by gender and location. Accordingly male households and farmers at Shalla district have the characteristics of early adopters compared to their counterparts. Therefore, agricultural development strategies should address the different categories of farmers and locations to promote successful hybrid maize adoption in the localities.

Using parametric duration model this study evaluated the factors influencing the time to adoption of hybrid maize. The factors that hastened adoption were found to be household size (defined by number of adults), access to extension services, input (seed) price, operated land and maize market participation whereas those delaying adoption were age of household head and livestock ownership. The role of extension training followed by factors related to household characteristics played dominant role in shaping the pace of maize technology adoption. This study suggests that measures to promote speedy adoption of hybrid maize fall primarily under provision of extension information and reorienting the mindset of the farmers towards market orientation and household labor efficiency. Extension efforts need to be strengthened to increase the flow of information to farmers. Also it may require concerted effort to provide proper training to farmers so as to make possible attitudinal changes towards technology adoption decision-making.

This study also generated another interesting finding which needs to be given due attention. In this regard, it should be noted that land and input (seed) price played diminishing returns to time of adoption of hybrid maize as their role in determining adoption time increases at a decreasing rate. This implies that policies promoting accelerated adoption of hybrid maize by smallholders should understand the nature and impact dimensions of different set of factors before implementing policy recommendations. This may require other studies on labor use efficiency.

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