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Determinants of the adoption of improved white haricot beans in East Shewa Zone, South-Eastern Ethiopia

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White haricot bean is a major source of food (protein) and income for the rural households of Ethiopia. Nationally, it is among the major pulse crops used for export. Despite its contribution, adoption of white haricot beans variety is very low. With this backdrop, this study analyzed the determinants of the decision to adopt and intensify the adoption of white haricot beans. A sample of 394 farm households were selected randomly proportional to their size in each sampled village. A double hurdle model is used to analyze the data. The findings reveal that the decision to adopt white haricot beans variety is influenced positively by frequency of extension visits, land size allocated to haricot beans, agricultural income, price perception, training obtained and perception on fertility enhancement benefit of the crop, and negatively by distant to market, ownership of haricot beans farm land (tenure) and nutritional perception of the crop. The intensity of adoption of white beans is affected negatively by the number of dependents in the household, ownership of haricot beans land (tenure) and positively by non-farm income and contact with non-governmental organisations (NGOs). The study recommends that appropriate measures should be taken to strengthen the extension services, provision of related trainings, improvement of existing infrastructures, family planning, more involvement of other NGOs (stakeholders) in the area, provision of the required inputs in time and quantity, and measures to reduce risks on output (loss) and market price in order to promote the adoption of white haricot beans in general.

Key words: White haricot beans, technology, decision to adopt, intensity of adoption, double hurdle model.

INTRODUCTION

Pulse crops are the most important source of food in the national diet of Ethiopia next to cereals. Nationally, pulses occupied 14% of the cultivated land yielding 2.86 million metric tons (11.4% of the total grain crop production) in 2013/14 *meher* season (CSA, 2014). Over the years 2006 to 2012, dry beans export value for Ethiopia increased from 20 to 100 million US dollar (FAOSTAT, 2015). Among pulses (dry beans), common (haricot) bean ranks third contributing about 9.5% of the total export value from agriculture in Ethiopia (FAOSTAT,

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2010). Despite its contribution, adoption of white haricot beans is very low.

Apart from climbing haricot beans that grow in western Ethiopian highlands and Metekel zone, haricot bean crop particularly grows (concentrated) in south-western (Wolayita and Sidama), rift valley (north-eastern) region, western lowland areas and eastern Hararghe zone of Ethiopia in sole and intercropped (widely) with maize and sorghum. Oromia region, especially east Shewa zone in the rift valley area is the major producer of white haricot beans, followed by Southern Nations, Nationalities and Peoples' Region (SNNPR) and Afar Region; the first two regions constituting nearly 85% of the total production (Setegn et al., 2010; Ferris and Kaganzi, 2008).

In Ethiopia, despite improvements over the past decade, about 46% of the population is undernourished, underscoring the importance of increasing domestic food productivity (WFP, 2013). The key constraints of agricultural productivity in Ethiopia include drought, a decline in soil fertility, poor linkage of input and output markets, low technology adoption rate (improved seeds, fertilizer, irrigation and modern agronomic practices), poor infrastructure (storage, processing, packaging and transportation) and market access, prevalence of pests and diseases, and low capacity and in-efficient governmental and private sector institutional services (Katungi et al., 2010; Dercon and Hill, 2009; Diao and Pratt, 2007; Odendo et al., 2004).

In relation to haricot beans, constraints on access to high yielding variety (due to higher seed price, poor quality, older and degenerated varieties), drought, poor soil fertility, poor linkage of input-output markets, and loss due to pests and diseases are the key causes of low productivity (Katungi et al., 2010; Fekadu, 2007).

A number of interventions have been identified and implemented to address some of the challenges that hamper haricot bean production in Ethiopia. The interventions included investment in the dissemination and promotion of existing technologies, improvement of infrastructures, strengthening market information, and informal seed systems, development and promotion of drought resistant varieties, and integrated soil and fertility management practices. For instance, in the rift valley region of Ethiopia, between 2004 to 2010, access to seeds on market demanded varieties has been increased from less than 20 to 60% across major beans growing areas by different actors (Katungi et al., 2010).

Although substantial amount of resources have been devoted to the development and provision of the required inputs over the past three decades, overall adoption rate of agricultural technologies has been lower for sub-Saharan countries, as compared to other parts of the world (World Development Report, 2008).

In Ethiopia, evidences indicate that the adoption rate of modern farm technologies including improved seeds is low. For example, at national level, the proportion of farm land area under different technologies such as fertilizer use, improved seeds, pesticides and irrigation in the *belg* season (2014) is 42, 5, 10 and 8%, respectively (CSA, 2014).

In light of this, this study was intended to analyze factors affecting the status and intensity of adoption of white haricot beans in the study area.

METHODOLOGY

Study area

The study area (east Shewa zone) is one of the administrative zones of Oromia Regional State. It is located in the south eastern part of Ethiopia. It extends between 7033'50''N-9008'56''N and 38024'10''E-400 05'34''E. It has a total area of 10,241 square kilometer and population of 1,208,825 with population density of 118 persons per km square. The average farm land holding size of the zone is about 1.5 ha per household which is relatively larger compared to the regional average of 1.0 ha per household (CSA, 2014). The zone covers about 8% of the cultivated area in Oromia region (CSA, 2014). Major crops grown in the area include cereals (*teff*, barley, wheat, maize and sorghum), pulses (soya bean, pea, green bean, horse bean and haricot (white and non white) beans, and vegetables and fruits (tomato, cabbage, potato, pepper, onion, carrot and papaya). The sizes (average) of crop land under cereals, pulses (including haricot beans), fruits and vegetables are provided in Annex 1.

Sample design and data source

Multi-stage sampling technique was used in selecting the units at different stages. The first stage involved a random sampling of three districts (27%) from 11haricot beans producing districts of east Shewa zone. The second stage involved a random sampling of three haricot bean producer farmer associations (villages) from each districts (a total of nine villages). Following the selection of villages, a random selection of adopters and non-adopters using Probability Proportional to Size (PPS) is made from each farmer association. Accordingly, the number of sample adopter and non-adopter farm households was 156 (one hundred fifty six) and 238 (two hundred thirty eight), respectively. Primary data of both qualitative and quantitative information were collected using a pretested questionnaire.

Model specification

According to Rogers (2003), "a technology is a design for instrumental action that reduces the uncertainty in cause-effect relationships involved in achieving a desired outcome". He goes on defining an innovation "as a thought, practice, or project that is perceived as new by an individual or other unit of adoption".

Further, innovation can be categorized into yield increasing, cost reducing, quality enhancing, risk reducing, environmental protection increasing, and shelf-life enhancing (Sunding and Zilberman, 2000). According to Feder et al. (1985), final adoption at the farmer's level is defined as the long-run degree of use of new technology given that the farmer has full information pertaining to the technology and its' potential uses. Technology adoption is a mental process through which an individual passes from first knowledge of an innovation to the decision to adopt or reject, and to confirm this decision (Ban and Hawkins, 1996).

Adoption refers to the decision to use a new technology, method, practice, etc. by a firm, a farmer or a consumer. Farm level

(household) adoption reflects a farmer's decision to incorporate a new technology into the production process. On the other hand, aggregate adoption is the process of spreading or diffusion of a new technology within a region or population. Therefore, a distinction exists between adoption at the individual farm level and aggregate adoption, within a targeted region or within a given geographical area (Feder et al., 1985)

The rate of adoption is defined as the proportion of farmers who have adopted a new technology. The extent of adoption is the percentage of farmers using a technology at a specific point in time (for example, the percentage of farmers using high yielding varieties). Based on Feder et al. (1985), definition of technology adoption (that is, for divisible technologies at farm household level), and the intensity of adoption of new high yielding variety is defined as the proportion (degree) of land allotted to the new technology (that is, from the total farm land size decided aprori) for this particular crop. The concept of adopters is meant for those farm households that produce any of or at least one of the export type high yielding white haricot beans varieties during the survey year, and at least two years before. The time limit is based on a study by Reilly and Schimmelpfennig (1999) that the adoption of a new variety of crop could take between 3 and 14 years. Intensity (degree) of adoption was measured in terms of the number of hectares covered by export type high yielding white haricot beans at farm household level.

Farmers adopt a given new technology if the utility (satisfaction) they derive in any form is higher than the local technology at hand. In modeling the satisfaction or utility derived from using the new varieties, the economic values or benefits associated with the high yielding variety over the traditional varieties needs to be considered. When confronted with a choice between two alternative practices, the i^{th} farmer compares the expected utility of the modern technology E_{mi} (W) to the expected utility of the traditional technology E_{ti} (W). Since the direct measurement of farmers' perceptions and risk attitudes on this particular technology are not available, inferences can be made for variables that influence the distribution and expected utility of the technology under long-run equilibrium (when the households have full information). These variables are used as a vector 'X's (attributes) of the choices made by farmer 'i', and ε_i is a random disturbance that arises from unobserved variation in preferences, attributes of the alternatives, and errors in optimization. Given the usual discrete choice analysis and limiting the amount of non-linearity in the likelihood function, E_{mi} (W) and E_{ti} (W) may be written as:

$$E_{mi}(W)=\alpha_{mi}X_{mi}+\varepsilon_{mi}$$
$$E_{ti}\ (W) = \alpha_{ti}X_{ti} +\varepsilon_{ti} \quad (1)$$

The difference in expected utility may be written as:

$$E_i\ (W) =E_{mi}\ (W) - E_{ti}\ (W) + \varepsilon_i = \alpha_i X_i +\varepsilon_i \quad (2)$$

Factors affecting the adoption of a farm technology has been widely analyzed using the Heckman (1979) and Tobin (1958) models. Heckman (1979) model is used with the assumption of selection bias in the process of adoption. Tobin (1958) model is the most widely used. The prime assumption for a Tobin (1958) specification is that farmers demanding modern technologies have unconstrained access to the technology. Studies show that underdeveloped input supply and marketing systems play on input choices and technology adoption in the case of smallholder agriculture (Asfawu et al., 2011; Shiferawu et al., 2008).

In situations where the input supply systems are undeveloped, farmers often face input access constraints. Tobin (1958) model does not distinguish households with a constrained positive demand for new technology from those with unconstrained positive demand and hence, assumes that a non adopter household is a rational decision maker. As a result, the Tobin (1958) model yields inconsistent parameter estimates in the situations of access constraints to get inputs (Croppenstedt et al., 2003).

The double hurdle model originally proposed by Cragg (1971) in addition to its assumption that the two decision tiers are not necessarily affected by the same set of factors, is a remedy to the problem of corner solution arising in the Tobit model, and has been extensively in use in several studies (Mignouna et al., 2011; Yu and Ninpratt, 2014; Martínez-Espiñeira, 2006; Moffat, 2003; Newman et al., 2001; Burton et al., 1996).

The first hurdle is to decide to be a potential adopter, while the second hurdle is how much (intensity) to adopt. The advantage with this approach is that it allows us to understand the characteristics of a class of households that adopted the technology, households wanting to adopt but reporting no positive use (due to access constraint) and households that have never adopted the technology (Yu and Nin-Pratt, 2014; Mignouna et al., 2011). However, it has not widely been used in the area of adoption of agricultural technologies with some exceptions (Yu and Nin-Pratt, 2014; Sosina et al., 2014; Asfawu et al., 2011; Berhanu and Siwnton, 2003).

This study used a double hurdle model assuming that factors that affect farmers' choice of adoption are not necessarily the same to the factors that affect the intensity of adoption. The adoption of export type white haricot beans variety is constrained by access to input (shortage and quality of the white High yielding variety, HYV) by the farm households (Katungi et al., 2010). The farm households need to cross two hurdles to adopt the white haricot beans high yielding variety.

A double hurdle model consists of two separate stochastic processes that determine the decision to adopt, and the intensity (degree) of use of a technology. The first hurdle is an adoption decision equation with a probit model. The model has an adoption (D) decision with an equation:

$$\begin{bmatrix} D_i = 1\ if\ D_i^{*} > 0\ and\ 0\ if\ D_i^{*} \le 0 \\ D_i^{*} = \alpha z'_i + U_i \end{bmatrix} \quad (3)$$

D_i^* being a latent variable that takes the value 1 if a farmer adopts the improved haricot beans technology and zero otherwise, z is a vector of household characteristics and α is a vector of parameters. The level of adoption (y_i) has an equation of the following:

$$\begin{bmatrix} y_i = y\ if\ > 0\ and\ D_i^{*} > 0 \\ y_i = 0, otherwise \\ y_i^{*} = \beta x_i' + V_i \end{bmatrix} \quad (4)$$

Where, y_i is the observed level (proportion) of white high yielding haricot beans variety, x is a vector of individual household characteristics and β is a vector of parameters. If the independence model works, the error terms U_i and V_i are distributed as follows:

$$U_i \sim N(0,1)\ and\ V_i \sim N(0, \sigma^2) \quad (5)$$

If both decisions are made jointly (the dependent double hurdle), the error term can be defined as:

$$(U_i\ V_i\ ) \sim \text{BVN (0, D) Where, D} = \begin{bmatrix} 1 & \rho\delta \\ \rho\delta & \delta^2 \end{bmatrix} \quad (6)$$

The model is termed as a dependent model if there is a relationship between the decision to adopt and the intensity of adoption. This relationship can be expressed as follows:

$$\rho = \frac{\text{cov}(U_i \ V_i)}{\sqrt{\text{var}(U_i) \ var(V_i)}} \quad (7)$$

If $\rho = 0$ and there is dominance (the zeros are only associated to non-participation, not standard corner solutions) then the model decomposes into a probit for participation and standard ordinary least square (OLS) for intensity of adoption. Based on Craggs (1971) proposal, the following equation integrates the probit model to determine the probability of $y > 0$ and the truncated normal model for given positive values of y.

$$f(w,y)|x_1,x_2) = \{1 - \phi(x_1\gamma)\}^{1(w-0)} [\phi(x_1\gamma)2\pi^{-\frac{1}{2}}\sigma^{-1} \exp\{-y - x_2\beta)^2 / 2\sigma^2\}/\phi(\tfrac{x_2\beta}{\sigma}]^{1(w-1)} \quad (8)$$

Where w is a binary indicator equal to 1 if y is positive and 0, otherwise. In Cragg (1971) model, the probability of y >0 and the value of y, given y>0, are determined by different mechanisms (the vector γ and β, respectively). Furthermore, there are no restrictions on the elements of x_1 and x_2, implying that each decision may even be determined by a different vector of explanatory variables altogether. Also, the Tobin (1958) model is nested within Cragg (1971) alternative because if $x_1 = x_2$ and $\gamma = \frac{\beta}{\sigma}$, the models become identical (Wooldridge, 2002). Fitting Cragg (1971) alternative requires the additional assumption of conditional independence for the latent variable's distribution, or:

$$D(y^*|\text{w, x}) = D(y^*|\text{ x}) \quad (9)$$

The same probabilities and expected values from Tobin (1958) model can be obtained by using the updated functional form. The probabilities regarding whether y is positive are:

$$P(y_i=0|x_{1i}) = 1 - \Phi(x_{1i}\gamma) \quad (10)$$

$$P(y_i>0|x_{1i}) = \Phi(x_{1i}\gamma) \quad (11)$$

The expected value of y, conditional on y > 0 is:

$$E(y_i|y_i >0, x_{2i}) = x_{2i}\beta + \sigma \times \lambda(x_{2i}\beta/\sigma) \quad (12)$$

where; $\lambda(C)$ is the inverse mills ratio (IMR)

$$\lambda(C) = \emptyset(c)/\phi(c) \quad (13)$$

where $\emptyset$ is the standard normal probability distribution function.

The "unconditional "expected value of y is:

$$E(y_i|x_{1i} , x_{2i}) = \phi(x_{1i}\gamma \{x_{2i}\beta+\sigma\times \lambda(x_{2i}\beta/\sigma)\} \quad (14)$$

For a given observation, the partial effect of an independent variable, x_j, around the probability that y > 0 is:

$$\frac{\partial P(y>0|x_1)}{\partial x_j} = \gamma_j \emptyset (x_1\gamma) \quad (15)$$

where γ_j is the element of γ reperesenting the coefficient on x_j. Equations 10, 11 and 12 are the same as the probabilities and partial effect from a probit regression of w on x_1. The partial effect of an independent x_j on the expected value of y, given $y > 0$, is:

$$\frac{\partial E(y_i|y_i>0,x_{2i})}{\partial x_j} = \beta_j [1- \lambda(x_2\beta/\sigma)\{ x_2\beta/\sigma + \lambda(x_2\beta/\sigma)\}] \quad (16)$$

Where β_j is the element of β representing the coefficient on x_j . Equations 12 and 16 are the same as the expected values, and partial effect from a truncated normal regression of y on x_2, with emphasis that the effect is conditional on y being positive. The partial effect of an independent x_j on the 'unconditional" expected value of y depends on whether x_j is an element of x_1, x_2, or both. First, if x_j is an element of both vectors, the partial effect is:

$$\frac{\partial E(y|x_1,x_2)}{\partial x_j} = \gamma_j \emptyset(x_1\gamma) \times \{x_2\beta + \lambda(x_2\beta/\sigma)\} + \phi(x_1\gamma) \times \beta_j [1- \lambda(x_2\beta/\sigma)\{ x_2\beta/\sigma)\}] \text{ if } x_j \varepsilon x_1, x_2 \quad (17)$$

If x_j is only determining the probability of $y > 0$, then $\beta_j = 0$, and the second term on the right-hand side of Equation 14 is canceled. On the other hand, if x_j is only determining the value of y, given that $y > 0$, then $\gamma_j = 0$; and the first right-hand side in Equation 17 is canceled. In either of the cases, the marginal effect is a function of parameters and explanatory variables in both tiers of the regression. After estimation of the double hurdle model, multivariate Tobin (1958) model is adopted to test the independence of the decision to adopt and intensity of adoption. The test statistic confirms the independence of the two tiers at 1% level of significance (Annex 2).

RESULTS AND DISCUSSION

Demographic characteristics of the farm households

91% of the sampled households in the study area are male headed, while the remaining 9% are female headed. Of the total 394 sample farmers, 156 are (one hundred fifty six) white haricot bean variety adopter farmers, of which 94 and 6% are male and female headed farm households, respectively. Within the remaining 234 (two hundred thirty eight) non adopters of white haricot bean variety, male and female headed farm households constitute 89 and 11%, respectively. There is a significant (5% level of significance) difference between the two groups of adopters and non adopters in terms of sex of the households (Table 1). Average age of the farm households in the study area is 40 years with minimum age of 21 and maximum of 75 years. The average age of the adopter farm households is about 40 years, whereas, that of the non adopters is 41 years. The result depicts that the farm households are in active working age category on average. The t-test statistics showed that there is no significant difference in terms of ages between adopters and non adopter farm households. The farm households have six family members on average. The average household size is slightly greater than the zonal (East Shewa) average of 5.04, regional average of 5.36 and national average of 5.04 (CSA, 2014). As revealed by the t-test, the average family size did not show variation among the groups of adopters and non adopter

Table 1. Descriptive statistics of the variables by adoption status of the households.

Variable	Unit	Mean		P- value t/Chi-square test
		Adopters (n=156)	Non-adopters (n=238)	
Dependent variables				
Adoption decision (adopstat)	Dummy (if adopted white haricot bean=1;otherwise=0)	0.40	0.6	-
Intensity of adoption (proporn)	Proportion (%) of land (that is, from total land under all haricot beans) allotted to white haricot beans	96	4	-
Explanatory variables				
Demographic characteristics				
Gender of the household head (sex)	Dummy (1=male; 0=female)	-	-	0.04**
Male	-	0.94	0.89	-
Female	-	0.06	0.11	-
Age of household head (age)	Years lived by the household head	39.7	41	0.21
Household size (Hsize)	Number	6.1	6.1	0.93
Working members of the household (Activelabor)	Number of household members with age>15 and age <65	2.9	3.1	0.4
Dependent members of the household (dependents)	Number of household members with age<15 and age >65	3.0	2.9	0.7
Economic characteristics				
Land holding size (Landhold)	Hectare	2.8	2.2	0.002***
Land under haricot beans (Hbfsizeha)	Hectare	0.82	0.46	0.00***
Livestock ownership (TLU)	TLU	8.7	7.2	0.01***
Household income from farming (Lnhhfincom)	Natural log of income from farming activities as a whole in ETB	61928	39092	0.00***
Household nonfarm income (Lnnfisize)	Natural log of income from nonfarm activities as a whole in ETB	2299	1636	0.2
Amount of credit used (Creditsize)	Amount of credit borrowed/utilized in ETB	1258.3	834	0.03**
Ownership of haricot bean farmland (tenure)	Dummy (owned=1; rented/leased-in=0)	-	-	0.00***
Owned	-	86.45	94.9	-
Leased in/share basis	-	13.5	5.1	-
Crop diversification (Diversifn)	Herfindal index	0.4	0.3	0.00***
Number of plots in different location (Fragmentation)	Number of plots owned	2.8	2.9	0.00***
Institutional characteristics				
Extension visits made (Extnuse)	Number of visits during crop season	2.4	1.7	0.00***
Distance to market (Dmkt)	Km	5.3	6.1	0.00***
Distance to development agents office (Distdaof)	Km	2.5	3.1	0.03**
Education of the household head (Educyr)	Years of schooling	4.2	3.8	0.2

Table 1. Contd.

Education of the family members (Educfam)	number of literates	3.7	3.7	0.91
Membership of cooperative/associations (asso)	Dummy (member =1; not member=0)	-	-	0.02**
Member of cooperative	-	75.6	63.4	-
Not a member of cooperatives	-	24.4	36.5	-
Farmer attributes				
Haricot beans farming experience (Hbexp)	-	13.1	12.3	0.42
General farming experience of the household head (Fexp)	-	21.5	21.7	0.83
Training attended by household head (training)	Dummy (attended=1; did not attend=0)	-	-	0.00***
Attended training	-	76.3	32.7	-
Did not attend training	-	23.7	67.3	-
Perception of the nutritional importance of haricot beans (nutrperc)	Dummy (perceived positively=1; did not perceive)	-	-	0.07***
Perceived as nutritious	-	56.7	67.2	
Did not perceive as nutritious	-	43.3	32.8	
Perception on yield of haricot beans (Yldperc)	Dummy (perceived positively=1; did not perceive)			0.00***
Perceived to give better yield	-	86	54.6	
Did not perceive better yield	-	14	45.4	
Perception on price of haricot beans (priceperc)	Dummy (perceived positively=1; did not perceive)	-	-	0.00***
Perceived better price	-	81	50	
Did not perceive better price	-	19	50	
Perception on soil fertility importance of haricot beans (fertperc)	Dummy (perceived positively=1; did not perceive)	-	-	0.00***
Perceived to enhance	-	93	64	-
Did not perceive to enhance	-	7	36	-

*, ** and *** indicate 10, 5 and 1% level of significance, respectively.
Source: Computed from own survey (2015).

farm households.

Economic characteristics of the farm households

The average land holding size of the farm households in the study area is 2.4 hectare with average of 2.79 ha for adopters, and 2.21 hectare for non adopter groups. The group test statistic shows that there is a significant (1% level of significance) difference in terms of land holding size between the two groups (Table 1).

Similarly, the average farm size under haricot beans is 0.60 hectare with the average of 0.82 hectares for adopters, and 0.46 hectares for non adopter groups. Similarly, the test statistic between adopters and non adopters reveal a significant (1% level of significance) difference among the groups in terms of land allotted to haricot beans cultivation.

The farm households have earned an average gross income of 50,510 (fifty thousand five hundred ten) birr from farming (that is, from crop sector, livestock, horticulture and other sectors such as forestry and beekeeping) during the year under study. Adopter farm households and non adopter farmers have earned about 61,927.00 (sixty one thousand nine hundred twenty seven) and 39,092 (thirty nine thousand ninety two) birr from farming in the same year respectively. Similarly, gross farm income of adopters is significantly (1% level of significance) higher than that of the non adopter farmers.

The gross non farm income of the farmers is about 1,967.00 (one thousand nine hundred sixty seven) birr on average. Similarly, the adopter farm households has earned better nonfarm income of 2,299 (two thousand two hundred ninety nine) birr as compared to the non adopter farm household's nonfarm income of 1,636.00 (one thousand six hundred thirty six) birr during the year, but not significant.

Existing land tenure (that is, possession for haricot beans farm) system in the area could be categorized as owned, leased-in and share cropping system. About 91% of the crop farms were owned, while the remaining 9% were either leased in and/or cultivated on sharecropping basis. There is a significant difference among the group of adopters and non adopters in terms of proportion of land tenure (ownership) system.

The average number of plots in different locations (fragmentation) for the farm households was three. There is a significant (1% level of significance) difference in mean fragmentation among the adopter and non adopter farm households (Table 1).

Major haricot beans varieties (types) widely cultivated in the study area include Awash-I, Awash Melkasa-II, red haricot beans, stripe color and black haricot beans. The frequency distribution of farmers by haricot bean types cultivated is given in Annex 4. Of the total farm households interviewed, about 30% of the famers cultivated Awash-I, 7% Awash-II, 57% red haricot beans, and 2% stripe (mixed) color haricot beans. When compared by adoption status, 30, 7 , 2 and 1% of the adopter farmers cultivated Awash-I variety, Awash Melkasa-II, mixture of Awash-I and Awash Melkasa-II, and Awash-I and red haricot beans respectively; while 58, 2 and 1% of the non adopter farmers cultivated the red haricot beans, mixed color; and red and awash-I varieties, respectively.

Institutional and infrastructural characteristics

The farm household heads had 4 years of education on average with a minimum of zero and maximum of 13 years of schooling. The group of white haricot beans variety adopter farm households has about 4.2 years of education (with minimum of zero and maximum of 13 years) whereas; it is 3.78 years of schooling for the non adopter farm households with minimum of zero and maximum of 15 years (Table 1).

There is no significant difference in years of education between adopter and non adopter farm households. Similarly, in terms of the number of literates in their family, the farm households have about 4 literate family members on average with minimum of zero, and maximum of 16 members. The number of literate family members is nearly similar for adopter and non adopter farm households (that is, equal to 4) on average. The test statistic revealed that there is no significant difference in terms of number of literate family members between adopter and non adopter farm households.

The average extension visits (frequency) by the development agents to the farm household was 2 during the production year. The record is significantly (1% level of significance) higher for adopter farm households as compared to the non adopter farm households (Table 1). The average distance of the farm households from the market is 5.7 kilometers (km) with a minimum distance of 0.25km, and maximum of 18 kilometers. The average distance from the market is about 5.3 and 6.1km for adopter and non adopter farm households respectively.

Similarly, the distance of the farm households' residence from the development agents' office is about 2.8 km on average with minimum distance of 0.01 km, and maximum of 16 km. It is 2.5 and 3.1 km for adopter and non adopter farm households respectively. Both distances from the market (at 1% level of significance) and distance from the development agent's office (5% level of significance) of the farm households are significantly shorter for adopter farm households compared to the non adopter farm households.

About 50% of the farm households have attended training on haricot beans production and related subjects on average; where the adopter farm households has the largest share (77%) compared to 33% for non adopter farm households. There is a significant (at 1% level of significance) difference among the two groups in terms of proportion of training attended.

68% of farm household heads were members of cooperative association; while the remaining 32% were non members. There is a significant (at 5% level of significance) difference in terms of proportion of membership in agricultural cooperatives among the group of adopters and non adopters.

Farm households' attributes

The overall experience of the farm households in farming is about 22 years in general; while the average years of experience in haricot beans farming in particular was 13 years. The average number of years on haricot beans farming is higher for the adopter (13 years) than non adopter (12 years) farm households (Table 1). There is no significant difference between the two groups of

adopters and non adopters of white haricot beans in terms of farming experience.

The farm households also expressed their perception on the different attributes of haricot beans crop in relation to its nutritional importance, yield, market price (profit) and land fertility enhancement capacity of the crop (Table 1). About 62% of the farm households perceived that haricot beans is nutritious; the percentage being significantly (at 1% level of significance) higher for the non adopter (67%) farm households compared to the adopter (57%) farmers.

Similarly, about 66% of the farm households perceived better yield from the crop; the perception being significantly (at 1% level of significance) higher for the adopters (86%) compared to the non adopter (55%) farm households. In relation to the market price (profit) of the crop, about 61% of the farm households perceived better price (profit); with a higher percentage of (81%) by the adopter farmers compared to the non adopters (50%).

Haricot beans belong to the leguminous crop category; well known for their nitrogen fixing capacity that in turn improves the soil fertility. As depicted in Table 1, of the total farmers interviewed, 74% of the farm households perceive that haricot beans have the capacity to enhance the fertility status of the land; the proportion being significantly (at 1% level of significance) higher for the adopter (93%) compared to the non adopter (64%) farm households.

Econometric

We have adopted Cragg (1971) tobit alternative model with the assumption of the independence of the two decision tiers (that is, the correlation between the decision to adopt and intensity of adoption is zero). The overall Wald chi^2-test of the Cragg (1971) model is significant at 1% level of significance (Annex 2). The result of the multivariate model (Table 2) reveals that the two decisions are significantly independent at 1% level of significance (Cappellari and Jenkins, 2006; Roodman, 2009). The Average Partial Effect (APE) for the significant variable is depicted in Annex 3.

Determinants of decision to adopt white haricot beans

Significant variables associated with the decision to adopt white haricot beans variety adoption are frequency of extension (extnuse) positively, distant to market (dmkt) in kilometers negatively, haricot beans farm size (hbfsizeha) in hectares positively, haricot beans farm land possession (tenure) system negatively, agricultural income of the household heads (lnhhfincom) positively, nutritional perception (nutrperc) negatively, price perception (priceperc) positively, training (training) positively and fertility enhancement perception (fertperc) positively of the farmers.

Frequency of extension service had a significant (positive) effect on the likelihood of adoption of white haricot beans. Provision of up-to-date information on production and marketing of white haricot beans variety, technical support and confidence building are usually done by the extension workers located at the village level. Previous studies by Tsegaye and Bekele (2012) and Mignouna et al. (2011) also showed similar (positive) association of extension service with the status of adoption of high yielding varieties.

Distance of the farm household residence from the market is significantly (negatively) related to the status of adoption of white haricot beans variety at 1 and 5% level of significance, respectively. Distance from the market of the farm households is expected to directly affect the transaction cost on input purchase and output marketing. The higher the distance from the market, the higher the transaction cost and lower the likelihood of adoption and intensity of white haricot beans variety. Results of similar previous studies (Ogada et al., 2014; Tsegaye and Bekele, 2012) also supported existence of inverse relationships between distance of the farmers from market and the likelihood of adoption of new crop variety.

Farm size (that is, land allotted for haricot beans as a whole) is significantly (highly and positively) related to the status of adoption of white haricot beans. The result revealed that the higher the farm size of the farm households (size of the land decided for the crop in general), the higher the likelihood of adoption of white haricot beans. This indicates that farmers who have previously devoted larger size of land for haricot beans cultivation in general are likely to adopt white haricot beans variety than farmers who cultivated traditional haricot beans on small pieces of land (even if they currently own larger size of land). A study by Katengeza et al. *(*2012) on adoption of improved maize variety also reveal that farm size is positively related to the decision to adopt.

Land tenure (possession) system is significantly (negatively) related to status of adoption of white haricot beans. Land possession (tenure) system refers to whether the land under white haricot beans is owned or not (rented-in or shared in). The study revealed that farmers who rented in or shared in land were likely to adopt white haricot beans variety. That is, a positive correlation was observed between rented in and/or crop-share land and status of adoption of white haricot beans. The fact that land ownership is negatively related to the decision to adopt might be attributed to differences in information on production and marketing of white haricot beans variety among the farmers.

Some farmers, irrespective of the size of their land, might have better access to information, better educated and had better information processing capacity to take the advantage of existing market opportunities on white

Table 2. Double hurdle model maximum likelihood estimate on determinants of adoption.

Variable	Coef.	Std. Err.	Z	P>z
Adoption decision				
Age	0.00	0.01	0.01	0.99
Gender	-0.42	0.29	-1.43	0.15
Hsize	-0.01	0.06	-0.23	0.82
Asso	0.04	0.19	0.20	0.84
Extnuse	0.10	0.05	2.00	0.04**
Educfam	0.01	0.05	0.29	0.77
Dmkt	-0.12	0.03	-3.62	0.00***
Credituse	0.05	0.19	0.26	0.79
Landhold	-0.03	0.09	-0.41	0.69
Hbfsizeha	0.64	0.36	1.78	0.07*
Tenure	-0.71	0.31	-2.32	0.02**
Fragm	0.04	0.06	0.64	0.52
Tlu	-0.02	0.02	-0.89	0.38
Lnnfisize	0.00	0.03	0.12	0.90
Hbexp	-0.01	0.01	-0.68	0.50
Lnhhfincom	0.69	0.20	3.43	0.00***
Comass	0.05	0.29	0.18	0.86
Nutrperc	-0.62	0.18	-3.40	0.00***
Priceperc	0.84	0.20	4.11	0.00***
Ngocont	0.07	0.21	0.35	0.72
Training	0.91	0.20	4.61	0.00***
Distdaof	0.04	0.03	1.20	0.23
Yldperc	0.36	0.24	1.51	0.13
Fertperc	1.04	0.24	4.35	0.00***
diversifn2	2.41	0.89	2.70	0.01***
_cons	-9.14	2.23	-4.10	0.00
Intensity of adoption				
Age	0.01	0.06	0.15	0.88
Gender	-0.50	0.86	-0.59	0.56
Activelabor	-0.83	1.06	-0.79	0.43
Dependents	-0.47	0.26	-1.82	0.07*
Extnuse	-0.13	0.26	-0.50	0.62
Educfam	0.89	0.69	1.29	0.20
Dmkt	-0.05	0.18	-0.26	0.80
Credituse	1.26	0.94	1.34	0.18
landhold2	-0.25	0.43	-0.58	0.56
Hbfsizeha	-0.03	1.15	-0.03	0.98
Tenure	-1.82	0.77	-2.36	0.01**
Tlu	0.08	0.17	0.46	0.64
Lnhhfincom	-0.52	1.01	-0.52	0.61
Lnnfisize	0.22	0.11	1.88	0.06*
Hbexp	-0.05	0.08	-0.69	0.49
Nutrperc	-0.37	0.86	-0.43	0.67
Priceperc	0.11	1.27	0.09	0.93
Ngocont	2.13	1.02	2.09	0.04**
Yldperc	0.14	1.28	0.11	0.91
Fertperc	-1.20	0.95	-1.27	0.20

Table 2. Contd.

diversifn2	0.10	3.15	0.03	0.98
_cons	107.23	10.57	10.15	0.00
Sigma	-	-	-	-
_cons	6.64	1.36	4.87	0.00

Number of obs = 394; Wald Chi^2 (25) = 167.71; Logpseudo likelihood = -670.31 Prob > chi2 = 0.00; *, ** and *** indicate 1,5 and 10% level of significance respectively.
Source: Computed from own survey (2015).

haricot beans. In addition, inverse relationship on the decision to adopt among land owners and those who obtained land through rent and crop share basis might also be attributed to the risk averse behavior of the land owners comparatively. Despite their resource position, farmers' decision on production is dependent on the prevailing risks such as output, price and etc.

Agricultural income of the households has a positive significant effect on the status of adoption of white haricot beans. In this study, agricultural income refers to all income derived from the agricultural sector (that is, crop, livestock and horticulture, etc...) excluding income derived from haricot beans and other non-farm incomes. The results show that farmers with higher agricultural income (that is, wealthier farmers) are more likely to adopt white haricot beans variety. Agricultural income helps them to cover the required expenditures (on seed, fertilizer, chemicals, for hiring labor and/or oxen, etc.) of the new technology under consideration. Previous study by Letaa et al. (2009) also show the occurrence of a significant positive correlation between agricultural wealth and adoption of common beans in Tanzania.

The nutritional perception of white haricot beans (compared to the non white haricot beans) is significantly (highly and negatively) related to status of adoption. As observed from the survey, farmers in the area prefer the traditional (nonwhite haricot beans) for food while production of white haricot beans is mainly for income generation.

On the other hand, price perception of white haricot beans are significantly (highly and positively) related to status of adoption of white haricot beans variety. The result reveals that farmers with positive perception of yield and market price of the crop were likely to adopt white haricot beans variety. Previous studies by Rahmeto (2007) and Otiento (2011) also confirmed the existence of positive relationship between market price perception of improved haricot beans and the likelihood of adoption.

Similarly, fertility enhancement perception of the farm households on the crop is significantly (highly and positively) related to status of adoption of white haricot beans. Farmers with positive perception of fertility enhancement capacity of white haricot beans are likely to adopt the new variety. Past study by Letaa *et* al. (2009) in Tanzania also show that there is a positive correlation between farmers fertility enhancement perception and adoption of improved common beans variety.

Training had a positive significant (highly) relation with the status of adoption of white haricot beans variety. Trainings on production (time of planting, weeding, application of chemicals, harvesting, threshing and storage), and marketing (grading and standardization, transporting) are provided to the farm households in Farmers Training Centers (FTC) by the extension workers, cooperative unions, and NGOs working on the subject. Farmers with better training status have better information and confidence and hence, are likely to adopt white haricot beans variety. Past similar studies by Awotide et al. (2012), Alemitu (2011) and Rahmeto (2007) also showed the positive association of training with the status of adoption of improved crop varieties.

In the first tier (decision to adopt), a unit increase in number of hectare of land allotted to haricot beans cultivation in general and income of the household from the farm sector (in ETB), increases the probability of adoption by 0.14 and 0.15 respectively; while a unit increase in distance of the households' residence from the nearest market (in km), decreases the likelihood of adoption by 0.03 (Annex 3).

The possibility that all individuals in the sample obtained extension service, perceived better price, perceived fertility enhancing benefit of haricot beans and obtained training increases the likelihood of adoption of white haricot beans by 0.02, 0.18, 0.23 and 0.19, respectively; while the possibility of owning land under haricot beans cultivation (tenure) and not perceiving the nutritional importance of white haricot beans, decreases the probability of adoption by 0.15 and 0.13, respectively (Annex 3).

Determinants of intensity of adoption of white haricot beans

In the second tier, the number of dependents in the households (dependents), tenure system (tenure), non farm income (lnnfisize) and contact with NGOs (ngocont) had a significant effect on the intensity of adoption of

haricot beans.

The number of the economically dependent family members (dependents) had a significant negative association with the intensity of adoption of white beans. The dependent portion of the family (children and aged members) requires special treatment (care) of the active family members incurring resources (time and money) of the farm households. Such shift of existing meager resources has a detrimental effect on acceptance and expansion of new farm technologies. The decision to adopt might not require more resource since one can begin cultivation on a very small farm size. However, when it comes to the second tier (intensity), the number of dependents had a significant negative association as expected.

Haricot beans farm land possession (tenure system), is negatively related to the intensity of adoption. Some of the farm households that owned the land and who decided to adopt white haricot beans cultivation on a portion of their land, might be relatively risk averse compared to those who cultivated based on rented-in and/or crop share basis. Such behavior halts them from allotting more land under the crop in fear of anticipated output loss, and market price reduction. Alternatively, households with rented-in and/or leased-in land might be risk takers, have better capacity to process and use information for decision making.

Nonfarm income had a significant (positive) effect on intensity of adoption of white haricot beans since extra income source gives them a better opportunity to purchase the required inputs for the technology and to rent in/ share crop more land. Results of previous studies (Awotidie et al., 2011; Diiro and Sam, 2014; Beshir et al., 2012) also confirm the existence of a positive relationship between nonfarm income and the intensity of adoption of improved varieties. Farm households can decide to adopt with available cash from farming and other sources initially. However, the influence becomes significant to put more land under cultivation on its effect on the purchase of the required inputs such as seeds, fertilizer and other chemicals. Moreover, income from the nonfarm sector could also serve to rent in more land from others thereby increasing the level of adoption.

Similarly, contact with other NGOs is significantly (positively) related to intensity of adoption of white haricot beans technology. The result reveals that farmers, who had contact with NGOs working on similar subject in the area, are likely to put more land under white haricot beans technology. Alemitu (2011) and Rahmeto (2007) in southern nation also found that contact with NGOs in this regard had a significant positive influence on the status of technology adoption. As part of capacity building programs, these farmers might have information/net-working/, obtained related trainings, awareness workshops, access to inputs (such as seeds and other chemicals) and other supports on production and marketing of haricot beans crop. Such supports might motivate the farm households to put more land under cultivation of the crop. As compared to its effect on decision to adopt, the significance of contact with NGOs on intensity of adoption might be related to confidence building on production and marketing of the crop, and support or capacity building through provision of key inputs such as seeds, fertilizer and other chemicals

Finally, crop diversification (measured in herfindhal index) has a highly significant positive relationship with the status of adoption of white haricot beans. Diversification might be linked to the risk-averse behavior of the farm households in terms of stabilizing the stream of their incomes over time in relation to the changing climate (output risk) and market prices of crops. Risk-averse behavior might not force the farm households to diversify more crops. The higher the crop diversification index, the lower the number of crops (common or traditional) grown by the households. Alternatively, the households might decide to adopt a new crop variety (that is, white haricot bean) in which they might have positive perception of the essential attributes (better confidence) of the crop. However, the variable does not have significant effect (that is, negligible) on the intensity of adoption, since their risk-averse behavior does not necessarily push the farm households to put more land under single crop.

In the first tier (decision to adopt), a unit increase in number of hectare of land allotted to haricot beans cultivation in general and income of the household from the farm sector (in ETB), increases the probability of adoption by 0.14 and 0.15 respectively; while a unit increase in distance of the households' residence from the nearest market (in km), decreases the likelihood of adoption by 0.03.

The possibility that all individuals in the sample obtained extension service, perceived better price, perceived fertility enhancing benefit of haricot beans and obtained training increases the likelihood of adoption of white haricot beans by 0.02, 0.18, 0.23 and 0.19, respectively; while the possibility of owning land under haricot beans cultivation (tenure) and not perceiving the nutritional importance of white haricot beans, decreases the probability of adoption by 0.15 and 0.13, respectively.

CONCLUSION AND RECOMMENDATIONS

Different factors (farm and farmer specific characteristics, farm household socio economic characteristics, infrastructural services, institutional factors, policy related factors and location variables) are associated to the adoption (that is, decision to adopt and intensity of adoption separately) of white haricot beans variety.

Frequency of extension contact, agricultural income of the farm household (other than from haricot beans), and trainings obtained, farm size under haricot beans and diversification positively have contributed to the decision

to adopt white haricot bean varieties.

Moreover, a positive perception of the farmers on price and fertility enhancement capacity of the crop compared to other crops played a significant role on the decision to adopt the crop. However, in environmentally (climate) fragile (risky) areas like this, farmers' positive perception of the output price do not sensitize them to intensify the cultivation of haricot beans. This might be due to the presence of a number of agricultural risks and uncertainty in the area. In theory, the optimal level of new technology use increases with higher output price if the elasticity of risk response to modern input is lower compared to the elasticity of the average yield response to modern input use.

The nutritional perception of white beans (compared to other non white beans), distance to market, and number of dependents in the family had negative repercussion on the adoption of the crop. Other sources of income (non farm income) also plays a positive role on the intensity of adoption. Contacts of the farmers with other nongovernmental organizations in this respect has a significant contribution on adoption and intensity of the crop in the area. This might call for drawing a lesson from the involved nongovernmental organizations for future use. Existing land possession (tenure) system has a negative association with the adoption and intensity of white haricot beans variety. Significant number of adopters of the crop possess land through rent and/ or crop share basis, the later being insignificant in number. This might be attributed to differences in information on the existing market, difference in capacity (financial, age, etc), risk behavior and/or other factors that exist among the land owners and the adopters.

Since the dissemination of the HYV (Awash 1 in1998 and Awash Melka in 2007) of white haricot beans in the area, the adoption of export type white haricot beans varieties has increased overtime. Awash 1 and Awash Melka are the dominant export type or canning white beans observed in the study area. The proportion of land under white beans has increased by 58% on average from the first year of adoption to the survey year (2014/2015), indicating a positive change in the intensity of adoption.

The following variables are found to be crucial among others, in influencing the adoption of white haricot beans. Agricultural and non agricultural income; relevant training (on production and marketing) provided, variables related to risk-averse behavior of farm households (such as tenure, crop diversification and perception on price); perception of farmers on the positive attributes of the crop (nutritional importance and soil fertility improvement contribution of the crop), the number of dependent family members (that is, on time and cost), existence of NGOs on capacity building in relation to the subject, and provision of extension service are the major ones. Moreover, constraints on the use of certified seeds as related to time and quantity of supply are major problems influencing the adoption of white haricot beans.

Based on the results of the study, the following measures are recommended to enhance the adoption of white beans variety in the study area. Given the high contribution of extension service on decision to adopt the crop, it is essential to further strengthen existing extension works in this respect. These can be done through increasing the frequency of extension visits (that is, via increasing the number of extension workers) and improvement of the quality of the extension services provided by the extension workers.

Quality improvement could be achieved via measures on the relevance of existing disciplines, provision of consecutive training to the extension workers, provision of required incentives, provision of other (material) capacity building to the development agents, and strengthening the monitoring and evaluation system of extension services. The perception of the farm households on the nutritional, fertility enhancement importance of the crop could also be improved through better extension services and relevant trainings.

In addition, enhancement of the involvement of NGOs working on similar issues and improvement of infrastructure (access to market as related to road and market centers or yards), provision of information on production and marketing are the appropriate measures to enhance the decision and intensity of adoption of white bean variety.

Moreover, measures to halt the negative consequence of the number of dependents in the farm households through appropriate family planning are important. The proportion of dependents (that is, for age less than 14) is nearly half of the population nationally, while the proportion of age greater than 65 is about 4%. The number of dependents in the first category could substantially be reduced through better family planning in the rural areas as first hand option. Problems related to the risk aversive behavior of the farm households could be reduced by suitable measures on price stabilization and measures related to output loss due to climate factors, crop diseases and pests in the mid and long-term. Other sorts of measures such as crop insurance are also crucial to minimize the risks on the farm households in the short and medium term. Depending on the economic progress and hard realities of the farm sector, subsidies on price of crops are also some of the long run solutions proposed to enhance the adoption of white haricot beans in the country.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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ANNEX

Annex 1. Land size (ha) under crops of the households (adopters=156; non adopters=238).

Crop		Mean	Std. Dev.	Min	Max
Cereals	Adopters	2.	1.9	0.25	10.45
	Non adopters	2.2	1.6	0.2	10.25
	Total	2.4	1.7	0.25	10.45
Teff	Adopters	0.74	1.13	0.00	8.00
	Non adopters	0.50	0.56	0.00	3.90
Barley	Adopters	0.09	0.20	0.00	1.70
	Non adopters	0.14	0.27	0.00	1.40
Wheat	Adopters	0.50	0.65	0.00	3.50
	Non adopters	0.45	0.7	0.00	5.20
Maize	Adopters	1.29	0.83	0.00	5.00
	Non adopters	1.1	0.8	0.00	5
Sorghum	Adopters	0.10	0.29	0.00	3.00
	Non adopters	0.11	0.35	0.00	4.30
Pulses	Adopters	0.8	0.7	0.25	5.00
	Non adopters	0.5	0.35	0.13	2.25
	Total	0.6	0.5	0.13	5
Soya bean	Adopters	0.01	0.08	0.00	1.00
	Non Adopters	0.00	0.03	0.00	0.40
Pea	Adopters	0.00	0.02	0.00	0.25
	Non adopters	0.00	0.02	0.00	0.25
Horse bean	Adopters	0.00	0.03	0.00	0.25
	Non adopters	0.00	0.00	0.00	0.00
Green Bean	Adopters	0.00	0.02	0.00	0.25
	Non Adopters	0.00	0.01	0.00	0.20
Traditional haricot bean	Adopters	0.03	0.12	0.00	1.00
	Non adopters	0.74	0.70	0.00	5.00
White haricot bean	Adopters	0.79	0.67	0.00	5.00
	Non adopters	0.02	0.15	0.00	2.10
Vegetables	Adopters	0.04	0.2	0.00	1.75
	Non adopters	0.01	0.05	0.00	0.38
	Total	0.02	0.12	0.00	1.75
Tomato	Adopters	0.02	0.12	0.00	1.00
	Non adopters	0.00	0.03	0.00	0.25

Annex 1. Contd.

Cabbage	**Adopters**	**0.02**	**0.13**	**0.00**	**1.50**
	Non adopters	0.00	0.04	0.00	0.60
Potato	Adopters	0.00	0.01	0.00	0.13
	Non adopters	0.00	0.00	0.00	0.00
Pepper	Adopters	0.01	0.05	0.00	0.50
	Non adopters	0.02	0.15	0.00	1.40
Onion	Adopters	0.00	0.02	0.00	0.25
	Non adopters	0.02	0.22	0.00	3.40
Carrot	Adopters	0.00	0.02	0.00	0.25
	Non adopters	0.00	0.00	0.00	0.00
Fruit (Papaya)	Adopters	0.00	0.01	0.00	0.13
	Non adopters	0.00	0.00	0.00	0.00
	Total	0.00	0.00	0.00	0.13
All crops	Adopters	3.5	2.2	0.5	12.58
	Non adopters	2.7	1.7	0.38	10.75
	Total	3.0	1.9	0.38	12.58

Source: Computed from own survey (2014).

Annex 2. Multivariate Tobit model output on the determinants of adoption of white haricot beans.

Variable	Coef.	Std. Err.	Z	P>z	(95% Conf.	Interval)
Adoption decision (Adopstat)						
Age	0.00	0.01	-0.38	0.71	-0.02	0.01
Gender	-0.01	0.18	-0.07	0.94	-0.37	0.35
Hsize	0.00	0.01	-0.35	0.73	-0.03	0.02
Asso	0.03	0.04	0.67	0.50	-0.05	0.10
Extnuse	0.06	0.03	2.07	0.04	0.00	0.12
Educfam	-0.02	0.03	-0.55	0.59	-0.07	0.04
Dmkt	-0.05	0.02	-2.85	0.00	-0.08	-0.02
Credituse	0.03	0.11	0.26	0.79	-0.19	0.25
landhold2	-0.01	0.05	-0.28	0.78	-0.12	0.09
Hbfsizeha	0.05	0.16	0.34	0.73	-0.26	0.37
Tenure	-0.31	0.17	-1.79	0.07	-0.65	0.03
Fragm	0.00	0.01	-0.38	0.70	-0.03	0.02
Tlu	0.00	0.01	-0.10	0.92	-0.02	0.02
Lnnfisize	0.00	0.01	-0.32	0.75	-0.03	0.02
Hbexp	0.00	0.01	0.45	0.65	-0.01	0.02
Lnhhfincom	0.44	0.12	3.79	0.00	0.21	0.66
Comass	0.07	0.07	0.99	0.32	-0.07	0.20
Nutrperc	-0.41	0.11	-3.64	0.00	-0.63	-0.19
Priceperc	0.60	0.14	4.40	0.00	0.33	0.86
Ngocont	0.20	0.11	1.78	0.08	-0.02	0.43
Training	0.11	0.04	2.89	0.00	0.04	0.19
Distdaof	-0.02	0.01	-2.11	0.04	-0.03	0.00

Annex 2. Contd.

Yldperc	0.32	0.15	2.09	0.04	0.02	0.62
Fertperc	0.78	0.16	4.99	0.00	0.48	1.09
diversifn2	1.66	0.49	3.39	0.00	0.70	2.62
_cons	-5.89	1.28	-4.61	0.00	-8.40	-3.39
Intensity of adoption (landpr0p)						
Age	-0.25	0.69	-0.37	0.72	-1.61	1.10
Gender	-17.82	18.72	-0.95	0.34	-54.51	18.87
Activelabor	-0.72	1.49	-0.49	0.63	-3.64	2.19
Dependents	-1.42	0.97	-1.46	0.14	-3.31	0.48
Extnuse	7.22	3.17	2.28	0.02	1.01	13.43
Educfam	1.52	2.96	0.51	0.61	-4.29	7.33
Dmkt	-6.14	1.78	-3.46	0.00	-9.62	-2.66
Credituse	6.44	11.34	0.57	0.57	-15.79	28.66
landhold2	-1.44	5.44	-0.27	0.79	-12.11	9.22
Hbfsizeha	1.87	16.34	0.11	0.91	-30.16	33.91
Tenure	-26.97	17.88	-1.51	0.13	-62.02	8.07
Tlu	0.33	1.19	0.28	0.78	-2.00	2.65
Lnhhfincom	48.40	11.80	4.10	0.00	25.26	71.53
Lnnfisize	-0.15	1.47	-0.10	0.92	-3.03	2.73
Hbexp	-0.43	0.74	-0.59	0.56	-1.88	1.01
Nutrperc	-37.92	11.55	-3.28	0.00	-60.55	-15.30
Priceperc	62.72	13.92	4.51	0.00	35.43	90.01
Ngocont	21.85	11.66	1.87	0.06	-1.00	44.69
Yldperc	35.72	15.62	2.29	0.02	5.11	66.33
Fertperc	74.20	15.91	4.66	0.00	43.01	105.38
diversifn2	204.48	50.63	4.04	0.00	105.25	303.70
_cons	-636.55	131.06	-4.86	0.00	-893.43	-379.68
/lnsigma1	-0.24	0.07	-3.44	0.00	-0.37	-0.10
/lnsigma2	4.39	0.07	62.92	0.00	4.26	4.53
/atrho12	2.03	0.08	24.35	0.00	1.87	2.19
sigma1	0.79	0.05	14.44	0.00	0.69	0.90
sigma2	80.79	5.64	14.33	0.00	70.46	92.63
rho12	0.97	0.01	173.46	0.00	0.95	0.98

Likelihood ratio test of rho12 = 0: chi2(1) = 521.175 Prob > chi2 = 0.0000.

Annex 3. Mean marginal effects of the probability, conditional and unconditional after double hurdle model for significant variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Overall probability pw1(Pry>0|x_{1i})	394	0.39	0.33	0	1
Overall expectation eyyx2(Pry>0|x_{1i})	394	98.48	2.15	90.59	104.77
Overall Un exp eyx1x2(Pry>0| x_{1i} ,x2i)	394	38.95	33.06	0	101.39
Prextnuse(Pry>0|x_{1i})	394	0.02	0.01	0	0.04
Expextnuse(Pry>0|x2i)	394	0.13	0	0.13	0.13
UncondExpextnuse (Pry>0| x_{1i} ,x2i)	394	2.12	1.45	0.13	4.08
Prdmkt(Pry>0|x_{1i})	394	0.03	0.02	0.05	0
Expdmkt(Pry>0|x2i)	394	0.05	0	0.05	0.05
UncondExpdmkt(Pry>0| x_{1i} ,x2i)	394	2.59	1.74	4.93	0

Annex 3. Contd.

Prhbfsizeha(Pry>0|x_{1i})	394	0.14	0.09	0	0.25
Exphbfsizeha(Pry>0|x2i)	394	0.03	0	0.03	0.03
UncondExphbfsizha(Pry>0| x_{1i} ,x2i)	394	13.61	9.17	0.03	26.01
Prtenure(Pry>0|x_{1i})	394	0.15	0.1	0.28	0
Exptenure(Pry>0|x2i)	394	1.82	0	1.82	1.82
UncondExptenure(Pry>0| x_{1i} ,x2i)	394	15.86	10.41	29.84	0
Prlnhhfincom(Pry>0|x_{1i})	394	0.15	0.1	0	0.27
Explnhhfincom(Pry>0|x2i)	394	0.52	0	0.52	0.52
UncondExplnhhfincom(Pry>0| x_{1i} ,x2i)	394	14.57	9.89	0.52	27.97
PrnutrPerc(Pry>0|x_{1i})	394	0.13	0.09	0.25	0
Expnutrperc(Pry>0|x2i)	394	0.37	0	0.37	0.37
UncondExpnutrperc(Pry>0| x_{1i} ,x2i)	394	13.37	8.94	25.44	0
PrPricePerc(Pry>0|x_{1i})	394	0.18	0.12	0	0.33
Exppriceperc(Pry>0|x2i)	394	0.11	0	0.11	0.11
UncondExppriceperc(Pry>0| x_{1i} ,x2i)	394	18.01	12.11	0	34.39
Prtraining(Pry>0|x_{1i})	394	0.2	0.13	0	0.36
Exptraining(Pry>0|x2i)	0	0	0	0	0
UncondExptraining(Pry>0| x_{1i} ,x2i)	0	0	0	0	0
PrfertPerc(Pry>0|x_{1i})	394	0.23	0.15	0	0.41
Expfertperc(Pry>0|x2i)	394	1.2	0	1.2	1.2
UncondExpfertperc(Pry>0| x_{1i} ,x2i)	394	21.82	14.89	1.2	42.01
Prdiversifn2(Pry>0|x_{1i})	394	0.52	0.35	0	0.96
Expdiversi~2(Pry>0|x2i)	394	0.1	0	0.1	0.1
UncondExpdiversifn2(Pry>0| x_{1i} ,x2i)	394	51.64	34.76	0.01	98.65
PrdePendents(Pry>0|x_{1i})	0	0	0	0	0
Expdependens(Pry>0|x2i)	394	0.47	0	0.47	0.47
UncondExpdependents(Pry>0| x_{1i} ,x2i)	394	0.47	0	0.47	0.47
Prlnnfisize(Pry>0|x_{1i})	394	0	0	0	0
Explnnfisize(Pry>0|x2i)	394	0.22	0	0.22	0.22
UncondExplnnfisize(Pry>0| x_{1i} ,x2i)	394	0.15	0.1	0	0.27
Prngocont(Pry>0|x_{1i})	394	0.02	0.01	0	0.03
Expngocont(Pry>0|x2i)	394	2.13	0	2.13	2.13
UncondExpngocont(Pry>0| x_{1i} ,x2i)	394	2.42	1.46	0	4.24

Source: Computed from own survey, 2014.

Annex 4. List of haricot beans varieties cultivated in the area.

Names of haricot bean varieties		Frequency	Percentage (%)
	Adopters	117	75.00
Awash-I	Non adopters	0	0
	Total	117	30
	Adopters	27	17.31
Awash Melka-II	Non adopters	0	0
	Total	27	7
	Adopters	0	0
Mexica-142	Non adopters	0	0
	Total	0	0

Annex 4. Contd.

	Adopters	3	1.92
Red haricot beans	Non adopters	226	94.96
	Total	229	58
	Adopters	0	0
Mixed (stripe color) haricot beans	Non adopters	9	3.78
	Total	9	2
	Adopters	0	0
Black haricot beans	Non adopters	1	0.42
	Total	1	0
	Adopters	6	3.85
1 and 2	Non adopters	0	0
	Total	6	2
	Adopters	3	1.92
1 and 4	Non adopters	0	0
	Total	3	1
	Adopters	0	0
4 and 5	Non adopters	2	0.84
	Total	2	0
Total		394	100