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# The role of education on the adoption of chemical fertiliser under different socioeconomic environments in Ethiopia

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**Abstract**

Studies on input adoption consider education as one of the most important factors that affect adoption decisions. However, very little is known about the spill-over effect of intra-household education on the adoption process and about the impact of education on adoption decisions under different socioeconomic conditions. We investigate these two issues using a discrete choice model. The results indicate that the decision making process is a decentralised one in which educated adult members of the household actively participate in the decision making process. This casts doubt on the traditional assumption that the household head is the sole decision maker. The results reveal that there is a substantial and statistically significant intra-household spill-over effect of education on the adoption decision of households. The results of the study also show that the coefficient of the education and the environment interaction variable is negative and statistically significant. This demonstrates that education and socioeconomic environments could be substitutes in modern environments and complementary in traditional ones. This implies that the expansion of education in traditional areas may be more attractive than in modern areas since education is usually the only means to enhance the ability of farmers to acquire, synthesise and respond to innovations such as chemical fertiliser.



*JEL classification:* Q12; I21; D13

*Keywords:* Adoption; Education; Intra-household education; Ethiopia; Socioeconomic environment

## 1. Introduction

The traditional economic theory of the firm, which presupposes perfect and free information, often sets aside the role of human capital or the differences in human factors from the analysis of production. Several studies on economic growth, however, confirm that one of the most important factors in economic development is human capital. Recent studies have also revealed that a large part of the growth of per capita income is attributable to the stock of productive skills and knowledge accumulated through education (e.g., see Appleton and Mackinnon, 1993; World Bank, 1990).

Education, broadly defined as 'all deliberate learning activities', is usually used as an approximation to human capital. As a result, most studies in the area of human capital use formal education (usually

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years of schooling) and informal education (age, experience, number of contacts between extension workers and farmers, etc.) to analyse the contribution of human capital to growth. The importance of education in contributing to the growth of national income was first recognised around the 1960s after researchers observed that the conventional factors of production, such as the growth of the stock of capital and the growth of the labour force, were unable to explain fully the growth in national income. Education was suggested to elucidate this unexplained residual (Appleton and Mackinnon, 1993). A study conducted by the World Bank based on an aggregate production function for the USA also showed that the growth of the US economy during the first half of the 20th century was attributable to the increase in the stock of human capital (World Bank, 1990). There is now a consensus that the accumulation of knowledge via education is an important factor of economic development.

In addition to its contribution to macroeconomic development, the importance of education at the micro (sectoral) level is also well documented. For instance, education is hypothesised to affect agricultural productivity by increasing the ability of farmers to produce more output from given resources and by enhancing their capacity to obtain and analyse information and to adjust quickly to disequilibria. Educated people are expected to perform certain jobs and functions with higher efficiency and are more likely to adopt new technologies in a shorter period of time than uneducated people. This is mainly because more educated people can gather, process, and interpret all available information, differentiate between promising and unpromising investment areas, and make decisions more easily with relatively small errors. Hence, education is expected to accelerate economic growth by enhancing the productive capabilities of all producers and by breaking the tight grip of custom and inefficient 'word-of-mouth' communication patterns. In addition, education improves the allocative and technical efficiency of producers by exposing them to a more systematic and dynamic production system and enhances their ability to choose the optimal bundle of input and output mix (Welch, 1970).

Education has also been considered as a major driving force in accelerating the process of economic growth in Ethiopia. If education is to play any significant role in Ethiopia, it has to be reflected in the agricultural sector where nearly half of the country's GDP originates, more than 90% of its export revenue is generated, and from which more than 80% of the employment opportunity is created. The transition from a centrally planned economy to a market economy has brought many economic changes that have direct bearings on the agricultural sector in Ethiopia. Even without these changes, the physical and demographic situations in which farmers have been operating are in continuous disturbance, necessitating permanent adjustment. The decline of crop yields as a result of soil degradation problems, the rapid decline in arable land-man and pastoral land-cattle ratios (Admassie, 1995), as well as the continuous redistribution of land can be cited as examples of disequilibria which demand the reaction of agricultural households. Education is expected to have a significant impact in such a dynamic environment since stationary technologies will be inadequate or become obsolete in new and dynamic situations (Azhar, 1991).

Since the Ethiopian agricultural system operates at a very rudimentary level, the introduction of new agricultural technologies has been accepted as one of the most important means of revitalising the sector. Because technological change expands the production possibilities, it is central to increasing agricultural production. However, the introduction of new technologies alone will not necessarily improve agricultural productivity and raise agricultural production. Observations show that farmers in Ethiopia have been very reluctant to adopt simple recommendations such as high yielding varieties and fertilisers. There is also a wide variation in the adoption of new technologies among different regions and among different households in the same region.

Adoption of agricultural production technologies, such as fertiliser, is influenced by a wide range of economic, social, physical and technical aspects of farming. Various studies have been undertaken to identify the factors that affect the reaction of agricultural households to disequilibria or to analyse factors that influence the adoption of new agricultural technologies (Rogers, 1962; Smoch, 1969; Weil, 1970; Falusi, 1974; Newbery, 1975; Tecle, 1975; Perrin, 1976; Waktola, 1980; Aklilu, 1980; Feder et al., 1985; Mekuria, 1995; Yirga et al., 1996; Asfaw et al., 1997; Tadesse, 2000). In almost all of these studies, education was taken as an important explanatory factor that positively affects the decision of households to adopt new agricultural technologies. However, all these studies consider only the educational level of the head of the household and completely disregard the contribution of other members of the household to the adoption decision. Moreover, the impact of education on the adoption of new technologies under different socioeconomic conditions has not been thoroughly investigated. We bridge these research gaps using a very rich data set collected by the Department of Economics of the Addis Ababa University (AAU) and University of Oxford from various parts of Ethiopia. The purpose of this article is to examine the impact of household members' education on the adoption decision and to assess the impact of education on farmers' adoption decisions under differing socioeconomic environments.

The organisation of the rest of the paper is as follows. Section two is devoted to a review of different studies of the relation between education and input adoption. The database for the study and the description of the study areas are presented in Section 3. Section 4 deals with methodology, measurement of variables and research hypotheses. Section 5 presents the empirical findings and Section 6 reports the conclusions and implications of the study.

## 2. Review of related works

Various studies of the factors that affect the adoption of agricultural innovations in developing countries have been conducted, focusing mainly on adoption constraints. The empirical results of most of the studies support the Schulz hypothesis that education increases "the ability to perceive, interpret, and respond to new events" (Schultz, 1981, p. 25). For instance, Evenson (1974, p. 276) concludes that "educated farmers adopt modern inputs earlier and applied them more efficiently throughout the adoption process". Falusi (1974, p. 15) finds that "fertiliser adoption is influenced more by institutional and educational considerations than by economic factors".

In Ethiopian, Tecle (1975), Admassie (1995), Mekuria (1995), Asfaw et al. (1997) and Tadesse (2000) have attempted to investigate the factors that affect farmers' adoption of new technologies, such as improved crop varieties and fertilisers. Tecle (1975), Mekuria (1995) and Asfaw et al. (1997) use probit and logit models, while Admassie employs a semi-log model. All conclude that education has a positive and significant impact on the adoption of modern inputs. More recently, Yirga et al. (1996) analyse the factors that influence the adoption of new technologies in the Wolmera and Addis Alem areas of Ethiopia. Their results reveal that "literacy is positively and significantly related to the intensity of use, but not significantly related to the probability of adopting improved wheat" (Yirga et al., 1996, p. 77).

Most of these studies attempt to explain the impact of education on the adoption of modern agricultural inputs by considering the educational level of the household head only. In other words, they did not try to examine the impact of the level of education of the other members of farm households on adoption decisions. For instance, Croppenstedt et al. (1999) consider education as one of the variables affecting the adoption of fertiliser technology in Ethiopia using data from rural households. They include in their model two indicators of education to capture the impact of information; a dummy variable reflecting the household head's reading and writing ability and two other dummy variables representing whether or not the household head has completed grade 4 or above and grade 6 or more. The results indicate that literate farmers and farmers with higher levels of formal education adopt fertilizer with a higher probability and use it more intensively than farmers who are less educated. However, the study has not considered the influence of the education level of other household members and assumes that the household head is not influenced by the education level of other members of the household.

Amha (1999) also considers the education variable as one of the possible determinants of improved seed adoption in Ethiopia. He divides the household heads in four regions of the country into literate and illiterate categories. The results of this study show that education is not a significant determinant of the adoption of improved seed in the four regions considered. This study, like the others, considers only the education level of the household head and ignores the education level of other members. However, recent studies (e.g., Basu et al., 1999, 2000) show the importance of the presence of educated members within households and the rational behind the involvement of these educated members in the decision making process of households.

In addition, most of the above studies do not explore the impact of education on the adoption of modern inputs under different socioeconomic environments. This is mainly because most studies are predominantly based on one or two districts. So, the spatial applicability of these results has been limited. The only exceptions in this respect are Lockheed et al. (1980) and Huffman (1977). Lockheed et al. (1980) capture the impact of education on farmers' efficiency under modernising and non-modernising environments using two different procedures. First, they divide the sample studies they review into modern and non-modern environments and examine how the contribution of education differs between the two. The second method they followed has two stages. First, they estimate the percentage increase in farm output per 4 years of education and then they regressed this on variables such as the adult literacy rate in the country, modernising environment, regional availability of extension services, etc. Huffman (1977) also investigates the interaction of education and extension contacts on the ability of farmers to adjust to disequilibria created by price changes and technological advances. However, he does not consider the impact of education on the adjustment to disequilibria under different environments.

The theories and the findings in this area are quite different. A frequently proposed argument states that the impact of education on the adoption of modern inputs and consequently on the efficiency is higher in modern environments than in traditional ones. Lockheed et al. (1980) for instance, conclude that:

> Under modernizing conditions, the effects of education are substantially greater than under traditional conditions. Over all the studies, the mean increase in output for four years of education under traditional conditions was 1.3 percent compared with 9.5 percent under modernizing conditions (Lockheed et al., 1980, p. 134).

The counter-argument emphasises that the impact of education is higher in traditional areas where production is bounded by backward cultural practices and where breaking with traditional thinking is essential for the dissemination of modern thinking. According to this line of argument, education may have insignificant effects in modern areas since farmers have various alternatives for learning, acquiring and using modern technologies. For instance, Kalirajan and Shand (1984) argue that:

> Survey evidence showed that most of the participants learned about the technology ... from mass media such as radio and news papers. Thus, mass media played an important role in providing information about the technology to farmers in the study area (Kalirajan and Shand, 1984, p. 238).

This echos the findings of many researchers on returns to education who conclude that the average rate of return to education is much higher in developing countries than in developed ones (e.g., see Pasacharopoulos, 1984).

## 3. Sources of data and the study areas

The main database for this study is the Ethiopian Rural Household survey conducted by the Economics Department of the Addis Ababa University, in collaboration with the Center for the Study of African Economies, Oxford University (CSAE), in 1993/1994. The data were collected by trained enumerators supervised by the staff of the department of economics using questionnaires which covered a broad range of socioeconomic aspects of the rural life from household composition and asset position to agricultural production and input utilisation.

Overall, 15 peasant associations (PAs)[1] were deliberately selected and covered by the survey. The sampled PAs are located in the four main regions of the country, which cover more than 80% of the country's rural population. Stratified random sampling was used in each village to take into account both female and male headed households. The detailed sampling procedure is discussed elsewhere (e.g., see Bigsten et al., 2002). The salient features of the PAs and the main attributes used to classify them into modern and traditional environments are presented in Table 1 and in Appendix A.

[1] Since the land reform proclamation of 4[th] March 1975, all Ethiopian farmers are organised in peasant associations.

Table 1
Regional distribution and demographic characteristics of the sampled peasant associations, 1994

| Name of the peasant association | Region | Zone | District | Total population | Number of households | Number of households surveyed |
|---|---|---|---|---|---|---|
| Adado | SNNPR | Gedeo | Yirgachife | 1803 | 365 | 133 |
| Aze Deboa | SNNPR | Kembata | Kedia Gemila | 6444 | 843 | 75 |
| Do'oma | SNNPR | N. Omo | Derimalo | n.a | 277 | 73 |
| Gara Goda | SNNPR | N. Omo | Bolosso | 13825 | 1750 | 95 |
| Debre Birhan | Amahara | N. Sewa | Debre Birahan | n.a. | n.a. | 183 |
| Dinki | Amahara | N. Sewa | Ankober | 643 | 138 | 87 |
| Shumsha | Amahara | N. Wello | Bugna | 2583 | 896 | 146 |
| Yetmene | Amahara | E. Gojam | Enemay | 562 | n.a. | 61 |
| Adele Keke | Oromia | E. Harerg | Kersa | 4500 | 1300 | 97 |
| Korodegaga | Oromia | Arssi | Dodota | 1400 | 304 | 108 |
| Sirbana Godeti | Oromia | S. Shewa | Adda | 1990 | 180 | 97 |
| Trufe Kechema | Oromia | E. Shewa | Shashemene | 2674 | 449 | 103 |
| Geblen | Tigray | E. Zone | Subhasasie | 2637 | 675 | 66 |
| Harresaw | Tigray | E. Zone | Atsbi | 4000 | 1100 | 83 |

*Source*: Computed from the 1993/1994 Ethiopian Rural Household Survey and Bevan and Pankhurst (1975). n.a.: not available.

## 4. Methodology, measurement of variables and hypotheses

### 4.1. Methodology

Our dependent variable is dichotomous, and equals 1 if the $i$th household has used modern agricultural inputs in the specified time period, and 0 otherwise. Hence, OLS estimation is inappropriate because some of the basic assumptions of the OLS method such as normality and homoscedasticity of the error term may be violated. Moreover, the computed probabilities may lie outside the 0–1 range (Greene, 1994). Probit and logit models are the most popular statistical models developed to analyse dichotomous response dependent variables. Let $Y_i^* = \beta' X_i + \mu_i$, where $Y_i^*$ is the dependent variable, $\beta$ is a vector of parameters to be estimated, $X_i$ is a vector of independent variables and $\mu_i$ is the error term. In practice, $Y_i^*$ is unobservable. What we observe is a dummy variable $Y_i$ defined by

$$Y_i = 1 \quad \text{if } Y_i^* > 0 \text{ (household } i \text{ used chemical fertiliser), and}$$
$$Y_i = 0 \quad \text{if otherwise.}$$

In this formulation

$$\begin{aligned}\text{Prob}(Y_i = 1) &= \text{Prob}(Y_0^* > 0) \\ &= \text{Prob}(\mu_i > -\beta' X_i) = 1 - F(-\beta' X_i)\end{aligned}$$

where $F$ is the cumulative distribution function of the error term $\mu_i$.

Various cumulative functions can be assumed for $F(\cdot)$. If we assume that $F(\cdot)$ has a logistic distribution,

$$\text{Prob}(Y_i = 1|X_i) = \frac{1}{1 + e^{-\beta' X_i}} = \frac{e^{\beta' X_i}}{1 + e^{\beta' X_i}}.$$

In the case of random sampling where all observations are sampled independently, the contribution of the $i$th observation is written as $P_i^{Y_i}(1 - P_i)^{(1-Y_i)}$ and the likelihood function will simply be the product of individual contributions. Thus, the likelihood function will be:

$$L = \prod_{i=1}^{n} P_i^{Y_i}(1 - P_i)^{1-Y_i}.$$

Taking logarithms and replacing $P_i$ by $e^{\beta' X_i}/(1 + e^{\beta' X_i})$, the log-likelihood function will be

$$\log L = \sum_{i=1}^{n} Y_i \beta' X_i - \sum_{i=1}^{n} \log(1 + e^{\beta' X_i}).$$

In binary dependent variable models, the $\beta$s cannot be interpreted as the marginal effects on the dependent variable. For instance, in the logit model, the marginal effect on the conditional probability is given by the rate of change in the probability as a result of a unit change in the dependent variable, i.e., $\mathrm{d}P/\mathrm{d}x$ is given by $\beta_j P_j(1 - P_j)$ (Gujarati, 1995; Greene, 1994; Mukherjee et al., 1998).

To test the reliability of the model one needs to conduct some diagnostic tests. Unlike the standard regression model, the $F$-test cannot be used to test the overall fitness in a discrete choice model. The most popular diagnostic test in such cases is the $\chi^2$ statistic defined as:

$$\chi^2_{(n)} = -2 \ln \frac{L_R}{L_U} = -2(\ln L_R - \ln L_U)$$

where $L_R$ and $L_U$ are the restricted and the unrestricted likelihood results, respectively (Mukherjee et al., 1998).

### 4.2. Measurement of variables and hypotheses

Descriptive statistics for the following dependent and explanatory variables across the sampled PAs are given in Table 2.

#### 4.2.1. Dependent variable

Adoption of chemical fertiliser input is taken as the dependent variable for this study. It equals 1 if the household used chemical fertiliser during the '*Meher*' or '*Belg*'[2] seasons in 1993/1994, and 0 otherwise.

#### 4.2.2. Explanatory variables

It is generally assumed that the desire to maximise the expected utility or profit of the household subject to various constraints determines the decision of the household to adopt new technologies. Based on this theory, the following explanatory variables are identified.

*Education.* Education is measured by the highest number of years of schooling completed by any adult (aged 15 and above) member of the household. In this study, the highest grade completed is preferred to the commonly used 'average number of schooling completed by household members', since it makes little sense to average the educational achievements of individuals.

To take into account the effect of intra-household literacy on the adoption decision, the education variable is further divided into two variables; the educational level of the head and the educational level of other adult household members. The educational level of the head is measured by the number of years of schooling that the head of the household has completed and the educational level of other household members by the highest number of years of schooling that any other household member above the age of 14 has completed.

It is hypothesised that education enhances the ability of farmers to acquire, synthesise, and quickly respond to disequilibria, thereby increasing the probability of adoption of an innovation. However, there are conflicting arguments as to whose education is decisive in the adoption decisions. Basu et al. (1999) argue that "... the advantages of literacy can spread to others in the household by virtue of certain kinds of decision-making on behalf of the household shifting toward the literate". We hypothesise that the decision whether to adopt an innovation or not is not necessarily made by the head of the household alone but also by other educated adult members of the household. It is therefore hypothesised that there could be a sharing of knowledge within households.

*Environment.* This variable is constructed to measure the socioeconomic development of different PAs so as to classify them as modern and traditional environments. Several attributes which indicate the social and economic development of the PAs were collected from primary and secondary sources to construct the environment variable. The basic steps followed to construct this variable can be summarised as follows:

(i) Ten variables which were believed to reflect the socioeconomic diversity of PAs were selected out of a range of several variables. Some variables, such as the distance from the PA to the regional capital and other institutions, were not included because of high collinearity problems. The selected variables are presented in Appendix A.

[2] Two cropping seasons are observed in the highlands of Ethiopia. The 'Meher' season is the main crop season stretching from June to October, while the 'Belg' season is a relatively less important and short crop growing season running from February to May.

Table 2
Descriptive statistics of selected variables

| Variable | Mean value |
|---|---|
| Proportion of households who used chemical fertiliser | 0.33 |
| Age of the household head | 46.46 |
| Gender of the head (1 if female and 0 otherwise) | 0.23 |
| Proportion of households who cultivated their own land | 0.93 |
| Highest formal schooling completed by any adult member (including the head) in years | 2.64 |
| Highest formal schooling completed by the head only (in years) | 1.04 |
| Highest formal schooling completed by other adult household member (in years) | 2.41 |
| Value of livestock if sold (in Birr[a]) | 1028.95 |
| Radio (1 if the household owns radio and 0 otherwise) | 0.06 |
| Area under cereal (in ha) | 1.15 |
| Credit (1 if any member of the household has taken out a loan of at least Birr 100[9] in the last 5 years before the survey and 0 otherwise) | 0.46 |
| Environment | 0.49 |
| Factor score based on factor analysis | −0.04 |

*Source*: Computed from the 1993/1994 Ethiopian Rural Household survey.
[a] US$ 1 was equivalent to Birr 5.50 at the time of the survey.

(ii) The average values of the selected variables were calculated and a value of 1 was given if the value of the variable for the PA under consideration was greater than the average (if the variable has a positive contribution to development), and 0 otherwise. However, if the variable was assumed to be negatively related to development, 1 was given for values less than the average and 0 otherwise. Variables which were assumed to have positive impact on development were road accessibility, availability of health and school services, proportion of tin roofed houses, number of radios and number of shops. The remaining variables, i.e., distance from Addis Ababa and from the district town and distance from the nearest market, were assumed to have a negative relationship with the level of development.
(iii) A mean value was calculated for each PA based on the results of step (ii).
(iv) Finally, an average value[3] for the thirteen PAs[4] was computed. Values above (below) the average indicate a relatively modern (traditional) environment. Therefore, 1 was given for above average values and 0 otherwise. Based on the above procedures, six PAs were classified as modern PAs and the remaining seven PAs as traditional (see Appendix A for the details). It is hypothesised that the probability of adopting modern inputs will be higher in modern environments than in traditional ones.

*Interaction variables.* To assess the impact of education on adoption decisions under different socioeconomic environments, an interaction variable is created as a product of the education and the environment variables. This variable is expected to measure whether the two variables are complementary or substitutes in the adoption decision. If the impact of education on the adoption of fertiliser is higher in modern environments, the coefficient of the interaction variable will be positive and significant. However, there are conflicting arguments about the sign of the interaction variable. It is, therefore, not possible to hypothesise a priori the sign of the coefficient of this variable.

*Land ownership.* This variable equals one if the household is the owner of the land, and 0 otherwise. There is conflicting theoretical and empirical evidence about the impact of tenure on adoption of agricultural innovations (e.g., Newbery, 1975; Feder

[3] Note that weighing is not used at each stage since it would require personal judgement or detailed investigation to attach a specific weight to each variable.
[4] Imdibir and Trufa Kecheme were excluded due to lack of information on the availability of social services.

et al., 1985). Therefore, no hypothesis is made about this variable.

*Gender of the household head.* This variable equals 1 if the household is female-headed, and 0 otherwise. Generally, it is hypothesised that male-headed households are more likely to get information about new technologies and take risky businesses than female-headed households.

*Age.* Age is defined as the age of the household head in years. Age is usually taken as a proxy for experience and is expected to have a positive impact on adoption. However, it is argued that there is a certain threshold of age beyond which the ability of farmers to take risk and adopt innovations decreases. This means that young farmers are more likely to face the risks associated with innovations (uncertainty in yield and unfamiliarity in technology) and to adopt them than their old counterparts. Therefore, the age variable is hypothesised to have a positive sign and its square a negative sign.

*Livestock.* It is measured by the value of all species of livestock[5] (if sold at the market price during the survey time) owned by the household. This variable increases the credit worthiness of households and their ability to undertake risky businesses. Thus, it is hypothesised to have a positive impact on adoption.

*Radio.* This variable equals 1 if the household owns a radio or tape recorder, and 0 otherwise. This variable is expected to reflect the household's access to information and its wealth position, and is expected to have a positive coefficient.

*Credit.* This variable equals 1 if any member of the household has taken out a loan of at least 100 Birr in the last 5 years before the survey.[6] It is supposed to have a positive impact on adoption of fertiliser.

*Area of land.* This is measured as the total area of land (owned and rented) under cereal cultivation. Plots of land used for permanent crops are not included since chemical fertiliser is rarely applied to such crops.

## 5. Empirical results

### 5.1. The intra-household externality of education

The results of the logit model are presented in Table 3. The null-hypothesis that all variables can be dropped is rejected at less than the 1% level of significance. The age and age square variables take the hypothesised signs, although both of them are insignificant. The coefficient of the gender variable takes the hypothesised negative sign but is not statistically different from zero. As hypothesised, the coefficients of the value of livestock and credit variables are positive and highly significant. This result implies that the higher the capacity of households to absorb risks associated with default and crop failure or the higher the availability of credit services, the greater the likelihood of adopting chemical fertiliser.

After controlling for the environmental variable, the impact of radio ownership on the adoption of fertiliser is not statistically significant. This implies that radio ownership has not been a serious constraint to the adoption of chemical fertiliser in the sampled areas. It may also indicate that most of the programs transmitted by the Ethiopian radio (the only radio channel in the country at least until 2001) are urban biased. The coefficient of the environmental variable, on the other hand, is positive and statistically significant at less than 1%. This is in line with our a priori expectation and implies that the probability of adopting fertiliser declines as one moves from modern to traditional environments.

As shown in Table 3, the coefficients of the educational variables are positive and significant indicating the importance of education in the adoption of chemical fertiliser. Interestingly, the coefficient of the educational level of adult household members except the head is much higher than the coefficient of the educational level of the household head both in terms of magnitude and statistical significance. Table 3 shows

[5] This way of measuring livestock is more transparent than the tropical livestock unit or the number of oxen as a means of approximating the capacity of the household to buy fertiliser, borrow money or to take risks.

[6] The first round survey did not collect credit data on yearly basis.

Table 3
Logit results on the intra-household impact of education on the adoption of chemical fertiliser

| Explanatory variables | Coefficient | *t*-ratio | Marginal effects† |
|---|---|---|---|
| Constant | −2.4339*** | −4.088 | |
| Age | 0.0041 | 0.187 | |
| Age square | −0.0001 | −0.071 | |
| Gender of the head (1 if female) | −0.0954 | 0.520 | |
| Land ownership | −0.2134 | 0.817 | |
| Highest schooling completed by the head | 0.0666* | 1.879 | 0.0146 |
| Highest schooling completed by members | 0.1260*** | 5.322 | 0.0276 |
| Value of livestock | 0.0004*** | 5.517 | 0.0001 |
| Radio | 0.2282 | 0.761 | |
| Area under cereal crops | 0.0505 | 0.772 | |
| Credit | 0.7626*** | 5.454 | 0.1671 |
| Environment | 1.0335*** | 6.742 | 0.2264 |
| Log-likelihood function | | −636.1998 | |
| Restricted log-likelihood | | −775.6416 | |
| $\chi^2$ | | 278.8835 | |
| Degrees of freedom (significance level) | | 11 (0.0000) | |

*Source*: Own computation.
† Marginal effects are shown only for significant coefficients.
* 10% level of significance.
*** 1% level of significance.

that a one grade increase in the educational level of any adult member in the household (except the head) is likely to increase the probability of adopting chemical fertiliser by 2.8 percentage points compared to only 1.5 percentage point in the case of the educational level of the household head only. The statistical significance of the former is also much higher than the latter. These results reveal that, even if the household head is illiterate, the presence of an adult literate person in the family plays a significant role in increasing the probability of the household to adopt chemical fertiliser. This is in line with the idea that an educated member of the household "confers a positive externality on the illiterate agents in the household by sharing the benefits of his or her literacy" (Basu et al., 2000, p. 2).

These results question the traditional thinking that the household head is the sole decision maker and only his/her educational level is the decisive factor in the adoption decision. This also implies that studies that do not take into account the educational level of adult family members of the household may be misspecified. The very high and positive coefficients of the educational level of other household members reveal that in the sampled areas the decision making process is decentralised and education is shared within households.

### *5.2. The impact of education on the adoption of innovations under different socioeconomic environments*

In order to analyse the impact of education on the adoption of fertiliser under different environments, data from 13 PAs spread all over the country comprising 1295 households were used. The 13 PAs were divided into modern and traditional environments using the method discussed in Section 4. Then an interaction variable between education and environment was created and used as an explanatory variable. Based upon our previous findings, education is measured in terms of the highest grade completed by any adult member of the household. Table 4 provides the result of the logit model.

The likelihood ratio tests provide evidence that the estimated coefficients are jointly significant. The signs and significance levels of most of the variables are almost similar to our previous results. As expected, environment and education variables have positive

Table 4
Logit results on the impact of education on fertiliser adoption under different socioeconomic environments

| Explanatory variables | Coefficient | $t$-ratio | Marginal effects† |
|---|---|---|---|
| Constant | −2.756* | −4.905 | |
| Age | 0.0119 | 0.567 | |
| Age square | −0.0001 | −0.459 | |
| Gender of the head (1 if female) | −0.09424 | −0.521 | |
| Land ownership | −0.1724 | −0.664 | |
| Highest grade completed by any adult member | 0.1804*** | 5.007 | 0.0392 |
| Value of livestock | 0.0005*** | 5.773 | 0.0001 |
| Radio | 0.2648 | 0.890 | |
| Area under cereal crops | 0.0474 | 0.721 | |
| Credit | 0.7475*** | 5.408 | 0.1626 |
| Environment | 1.3607*** | 7.234 | 0.2959 |
| Interaction between education and environment | −0.1101*** | −2.557 | −0.0239 |
| Log-likelihood function | | −639.8402 | |
| Restricted log-likelihood | | −775.6416 | |
| $\chi^2$ | | 271.6028 | |
| Degrees of freedom (significance level) | | 11 (0.0000) | |

*Source*: Own computation.
† Marginal effects are shown only for significant coefficients.
* 10% level of significance.
*** 1% level of significance.

and statistically significant impact on the adoption of chemical fertiliser.

One of the most interesting findings of this section is the negative and significant coefficient of the education and the environment interaction variable. This result, coupled with the positive and significant coefficients of the education and the environment variables, implies that education and environment variables are substitutes in modern environments and complementary in traditional ones. Specifically, the results show that a one grade increase in the highest grade completed by any adult member in the household increases the probability of adopting chemical fertiliser by only 0.0153 (0.0392–0.0239) in modern environments. However, in traditional environments the impact of a one grade change on the probability of adopting chemical fertiliser is 0.0392. This means that the impact of education on the probability of farmers' adoption of chemical fertiliser is more than twice as high in the relatively backward areas than in the relatively modern areas. This result clearly demonstrates that the role of education is rather low in increasing the probability of farmers' fertiliser adoption in modern environments compared to traditional areas. This implies that the advantage of education in encouraging farmers living in modern areas to adopt chemical fertiliser is eroded by the availability of other infrastructures.

The robustness of our results is examined by measuring the environmental variable in continuous fashion using the scores of a factor analysis. It is argued that categorising all the PAs into two groups only (modern and traditional) may disguise the socioeconomic variation that exists among PAs. Therefore, factor analysis is used to reduce the ten socioeconomic indicator variables to factor scores. The factor score of each PA is then used as an indicator of the socioeconomic development (environment) of the PA. An interaction variable is also created by multiplying the factor scores by the highest grade completed in each household. The results of this exercise are presented in Appendix B, and are mostly consistent with our previous findings. Education and environment have positive and statistically significant influences on the probability of adopting chemical fertiliser. The education and environment interaction variable is also negative and statistically significant at less than 1%. These results strengthen our previous finding that the role of education in increasing the probability of households to use chemical fertiliser is higher in relatively backward areas.

## 6. Summary and conclusions

Introducing new varieties of inputs and modern technologies alone may not increase food production or improve the efficiency of farmers since there might be great difficulty on the part of the inexperienced and uneducated farmers to understand, accept and properly utilise such innovations. Various studies have been conducted to analyse factors that influence the adoption of new agricultural technologies. In most of these studies, education is considered an important explanatory factor that positively affects the decision of households to adopt new agricultural technologies. However, very little is known about the spill-over effect of the educational level of other adult members on the adoption decision of the household, since usually the household head is implicitly assumed to be the sole decision maker. More importantly, the impact of education on the adoption of new technologies under different socioeconomic conditions has not been thoroughly investigated.

To examine the intra-household externalities of education in the adoption decisions, the impact of the educational level of the head of the household and that of other household members aged 15 and above are compared. The logit model results reveal that the educational level of other adult household members has stronger impact on fertiliser adoption than the educational level of the head of the household. Specifically, the results show that, *ceteris paribus*, a one grade increase in the educational level of the adult household member with the most education (except the head) increases the probability of adopting chemical fertiliser by 2.7% compared to 1.5% in the case of the educational level of the head of the household only. These results show that there is a substantial amount of intra-household externality from the educational levels of other adult household members. This casts doubt on the traditional thinking that the household head is the sole decision maker and only his/her educational level is the decisive factor in the adoption decision. This also implies that studies that do not take the educational levels of all adult members of the household into account may suffer from misspecification.

An attempt was also made to identify the impact of education on the adoption of fertiliser under different socioeconomic environments. The results of the study show that the coefficients of the education and the environment variables are positive and statistically significant but the coefficient of their interaction variable is negative and highly significant. These results reveal that education and environment variables are substitutes in modern environments and complementary in traditional ones. This implies that the role of education in increasing the probability of adopting chemical fertiliser is substituted or eroded by other factors, such as mass media, traders, etc., in modern environments. However, in traditional areas where these facilities can hardly reach the farmers, the role of education in encouraging them to adopt innovations is critical. In traditional areas where the importance, method of application and even the existence of modern inputs such as fertiliser are not well known, adoption requires a considerable amount of effort. Education helps farmers to adopt innovations in unfavourable environments by improving their ability to collect and synthesise information and by giving them the courage to break the traditional 'crust of custom'.

This result also suggests that policy makers might fruitfully place much emphasis on expanding primary education and increasing the enrolment rates in relatively backward areas to increase the probability that farmers in such areas will adopt innovations such as chemical fertiliser. This implies that the expansion of education in traditional areas is more attractive (at least in persuading farmers to adopt modern inputs) than in modern areas. This is mainly because education is usually the only means to break traditional thinking in backward areas. The robustness of these results is also checked by measuring environment in a continuous fashion based on factor analysis.

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## Appendix A. Variables used to classify the peasant associations as modern or traditional

| Name of peasant association (PA) | Distance from Addis Ababa (km) | | Distance from the district town (km) | | Road accessibility (1 if AWR) | | Number of: Elementary school | | Number of: Clinic | | Distance from the nearest high school or hospital | | Percentage of tin roofed houses | | Number of radios | | Number of shops | | Distance to the nearest market | | Total value of dummies | Decision |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AV | DV | AV | DV | AV | DV | AV | DV | AV | DV | AV | DV | AV | DV | AV | DV | AV | DV | AV | DV | | |
| Adado | 386 | 0 | 10 | 1 | AWR | 1 | 1 | 1 | 1 | 1 | 25 | 1 | 6 | 0 | 5 | 0 | 1 | 0 | 0 | 1 | 6 | Modern |
| Aze Deboa | 359 | 1 | 4 | 1 | AWR | 1 | 1 | 1 | 0 | 0 | 70 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 5 | Modern |
| Do'oma | 492 | 0 | 2 | 1 | DWR | 1 | 1 | 1 | 0 | 0 | 102 | 0 | 7 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 4 | Traditional |
| Gara Goda | 378 | 0 | 11 | 1 | AWR | 1 | 1 | 1 | 1 | 1 | 43 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 12 | 0 | 4 | Traditional |
| Debre Berhan | 110 | 1 | 10 | 1 | AWR | 1 | 1 | 1 | 1 | 1 | 10 | 1 | 25 | 1 | 32 | 1 | 0 | 0 | 10 | 0 | 8 | Modern |
| Dinki | 153 | 1 | 25 | 0 | NR | 0 | 0 | 0 | 0 | 0 | 66 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 8 | 0 | 1 | Traditional |
| Shumsha | 630 | 0 | 12 | 1 | DWR | 1 | 1 | 1 | 0 | 0 | 110 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 12 | 0 | 3 | Traditional |
| Yetmen | 250 | 1 | 15 | 0 | AWR | 1 | 1 | 1 | 1 | 1 | 15 | 1 | 90 | 1 | 2 | 0 | 10 | 1 | 0 | 1 | 8 | Modern |
| Adele Keke | 510 | 0 | 15 | 0 | AWR | 1 | 1 | 1 | 1 | 1 | 27 | 1 | 75 | 1 | 6 | 0 | 8 | 1 | 0 | 1 | 7 | Modern |
| Korodegaga | 128 | 1 | 25 | 0 | NR | 0 | 1 | 1 | 0 | 0 | 30 | 1 | 30 | 1 | 5 | 0 | 1 | 0 | 8 | 0 | 4 | Traditional |
| Sirbana Godeti | 57 | 1 | 10 | 1 | AWR | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 55 | 1 | 14 | 1 | 5 | 1 | 2 | 1 | 8 | Modern |
| Geblen | 898 | 0 | 22 | 0 | DWR | 1 | 0 | 0 | 0 | 0 | 25 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 20 | 0 | 2 | Traditional |
| Harresaw | 869 | 0 | 17 | 0 | AWR | 1 | 1 | 1 | 1 | 1 | 40 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 18 | 0 | 4 | Traditional |
| Average value over all PAs | 376.2 | | 12.6 | | | | 0.75 | | 0.43 | | 41.1 | | 21.5 | | 6.6 | | 2.1 | | 6.4 | | 5.07 | |

*Source*: Own computation. AWR: all weather road, DWR: dry weather road; NR: no road, AV: average value, DV: dummy value.

## Appendix B. Robustness of results when the environment variable is measured by factor analysis score of PAs

| Explanatory variables | Coefficient | *t*-ratio | Marginal effects† |
|---|---|---|---|
| Constant | −1.6240*** | −3.015 | |
| Age | 0.0074 | 0.347 | |
| Age square | −0.0001 | −0.211 | |
| Gender of the head (1 if female) | −0.1581 | −0.878 | |
| Land ownership | −0.4408* | −1.708 | |
| Highest grade completed | 0.1167*** | 5.663 | 0.0258 |
| Value of livestock | 0.0005*** | 7.194 | 0.0001 |
| Radio | 0.2557 | 0.844 | |
| Area under cereal crops | −0.1059 | −1.650 | |
| Credit | 0.8315*** | 5.873 | 0.1837 |
| Environment (factor analysis score) | 0.6500*** | 6.189 | 0.1436 |
| Interaction between education and environment | −0.03519* | −1.845 | −0.0078 |
| Log-likelihood function | | −642.3008 | |
| Restricted log-likelihood | | −775.2092 | |
| $\chi^2$ | | 265.8169 | |
| Degrees of freedom (significance level) | | 11 (0.0000) | |

*Source*: Own computation.
† Marginal effects are shown only for significant coefficients.
* 10% level of significance.
*** 1% level of significance.

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