Education and Agricultural Technology

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Abstract

I use household survey data from Ethiopia to study the effect of education on the adoption of five agricultural technologies: improved seeds, fertilizer, preventative measures (e.g. pesticides), extension programs, and irrigation. To account for possible omitted variable bias I use household distance from government primary and secondary schools as instruments for education. The estimates indicate that overall education has a positive effect on all agricultural technologies studied, except for the use of agricultural extension programs for which education has a negative effect. Looking into heterogeneous effects of education across crops reveals that education has a positive effect on adoption of most technologies for major staple crops but a negative effect for non staple crops.

1 Introduction

The agricultural sector is important to many countries, especially developing countries. The World Bank has found that 65% of poor working adults made a living through agriculture, and in some countries agriculture accounted for more than 25% of GDP [1]. It is no surprise then to see that there is evidence that the use of modern agricultural technologies, such as improved seeds and fertilizers, has increased economic growth [2]. However, the majority of smallholder farmers rely on traditional methods of production [3]. Understanding the factors that affect the adoption of agricultural technology could therefore play an important role in efforts to increase economic growth.

One particular factor that could influence the adoption of agricultural technologies is education. More education could make a farmer more open minded and better able to rationally evaluate the benefits of technology. However, there have been conflicting results on the effects of education on the adoption of technology [3].

One example of a paper that argues that education increases is Egge et al.'s paper [4] which investigates factors that affect the use of improved sorghum seeds by looking at a survey from the Awbare district of Ethiopia. This paper, however, could be improved upon; it has a small sample size ($n = 180$), and it only looks at education in terms of literacy instead of years of formal education. The biggest issue with this paper is that it does not account for any endogeneity between education and the adoption of agricultural technology. There is a possibility of omitted variable bias arising from people who are more traditionally minded and/or less trustful choosing to not both not receive an education or use agricultural technologies.

My paper will contribute to the literature by trying to address the issues with the aforementioned paper. I will use a large panel data set with survey data across Ethiopia to examine how education affects a variety of agricultural technologies such as the use of improved seeds and fertilizer. In order to account for possible omitted variable bias I will use household distance from government primary and secondary schools as instruments for education.

The rest of the paper is organized as follows. Section 2 describes the data and gives descriptive statistics. Section 3 explains the identification strategy and estimating equations. Section 4 gives the estimates and adresses instrument validity. Section 5 explores heterogeneous crop effects. Section 6 concludes.

2 Data Description

I use data from three waves of the Ethiopia Socioeconomic Surveys which together forms a set of panel data [5]. The surveys were taken in 2011-2012, 2013-2014, and 2015-2016. These surveys are a part of the World Bank's Living Standard Measurement Study (LSMS). They provide household and community level data with a special focus on agricultural statistics which allows me to have observations at a field level.

First I connected each field that the household owns to the household member in charge of the field. Wave 2 and Wave 3 of the surveys includes information on which household member that makes decisions on the inputs for each field that the household owns. In order to get this information for Wave 1 I used the fact that most households only have one single person manage the decisions for all of their fields and reasoned that it was unlikely for this person to have changed over the span of a single year. For each household in the Wave 2 data I took the person who was in charge of most of the fields that the household owns and assigned that person as the decision maker for all of the fields for the household in Wave 1. I first experimented with this method by taking the mode of Wave 3 household decision makers and matching it to Wave 2 decisions makers. I found that the match rate was 93%.

The main variable of interest is education. The data set only includes information on the highest grade completed by each individual so I manually changed each of these grades into years of education using Table A.1. There are five agricultural technology variables: improved seeds, fertilizer, extension program, preventative measures (e.g. pesticides), and irrigation. Each of these are dummy variables that are 1 if used on the field and 0 if not. In addition to these variables I also use variables that measure distance from government primary school and distance from government secondary schools as instruments for education. These variables measure the households distance from the schools in kilometers. If the schools are in the same community as the household the distance is reported as zero . The descriptive statistics are reported in Table 2.1.

Table 2.1: Descriptive Statistics

	Mean	SD	Min	Max	N
Agricultural Technologies					
Improved Seeds	0.04632	0.21019	0	1	73028
Fertilizer	0.51678	0.49972	0	1	71814
Preventative Measure	0.15930	0.36596	0	1	72989
Extension Program	0.17117	0.37666	0	1	71806
Irrigated	0.03903	0.19366	0	1	71771
Education Variable					
Education (Years)	2.17944	3.42701	0	19	71429
Instrument Variables					
Primary School (km)	0.75149	2.73838	0	40	72760
Secondary School (km)	11.20878	11.56007	0	108	72929

Note: An observation is a field and a year

3 Empirical Strategy

The main challenge of estimating the causal effect of education on the adoption of agricultural technology are issues of omitted variable bias resulting from education. There is a potential issue of trust and/or traditionally mindedness not being accounted for. People who are distrustful and/or traditionally minded may choose to not receive an formal education nor use modern agricultural technologies due to the fact that they either do not trust them or are steadfast in traditional ways. To address this concern I instrument education using distance from government primary and secondary schools. The basic idea behind this is that being closer to schools should increase the likelihood of one going to school and therefore should increase education. The estimating equations are:

$$T_{tvf} = \beta \ E_{tvf} + \mathbf{X}_{tvf}\Gamma + \alpha_t + \alpha_v + \varepsilon_{tvf} \tag{1}$$

$$E_{tvf} = z_1 \ P_{tvf} + z_2 \ S_{tvf} + \mathbf{X}_{tvf}\Gamma + \alpha_t + \alpha_v + \nu_{tvf} \tag{2}$$

Equation (1) is the second stage of the 2SLS and equation (2) is the first stage. The index t denotes years, v denotes villages (specifically wards of Ethiopia known as Kebele), and f denotes the specific field owned by a household. The dependent variable T_{tvf} is an indicator variable that equals one if a specific agricultural technology is used on field f in time t. E_{tvf} is the endogenous variable of interest, the formal education measured in years of the primary decision maker of field f in time t. $\mathbf{X}_{tvf}$ is a set of field-year covariates. α_t denotes time fixed effects and α_v denotes village fixed effects. P_{tvf} and S_{tvf} are the instruments which denote the distance from government primary schools and secondary schools, respectively, of the decision maker of field f in time t. The coefficient of interest, β, estimates the effect of an increase of education by one year on the likelihood of adopting a specific agricultural technology on a field.

In order for distance from schools to be valid instruments for education they must satisfy three requirements: instrument relevance, exogeneity, and the exclusion restriction. These will be addressed in section 4.3.

4 Baseline Estimates

4.1 Initial OLS estimates

Initial OLS estimates of equation (1) are reported in Table 4.1. Education has a statistically significant positive effect on the adoption of all agricultural technologies except for the use of extension programs which reports a statistically insignificant estimate.

Table 4.1: Initial OLS Estimates

	Improved Seeds (%)	Fertilizer (%)	Extension (%)	Prevent (%)	Irrigated (%)
	(1)	(2)	(3)	(4)	(5)
Education	0.225***	0.508***	0.012	0.386***	0.070**
	(0.036)	(0.075)	(0.056)	(0.056)	(0.032)
Constant	1.428	53.051***	42.858***	30.419***	5.043***
	(0.922)	(2.019)	(1.558)	(1.649)	(0.705)

Note: *** p<0.01, ** p<0.05, * p<0.10

4.2 2SLS Estimates

The First Stage estimates are included in Table 4.2 and the Second Stage estimates in Table 4.3. Column (2) of the first stage table indicates that when fixed effects are included that the effects of distance from schools on education are negative and statistically significant. This is expected as the further away one is from school the less likely they would go to school and receive education. These effects being statistically significant in explaining education shows that distance from schools satisfies the instrument relevance required for IV.

Table 4.2: First Stage Estimates

	Education	
	(1)	(2)
Primary School Dist. (km)	0.029***	-0.023***
	(0.004)	(0.003)
Secondary School Dist. (km)	-0.035***	-0.007***
	(0.001)	(0.001)
Constant	2.552***	3.428***
	(0.019)	(0.119)
FE	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10

The Second Stage estimates shows that education is statistically significant and positive on all agricultural technologies except for the use of an extension program which is significant and negative. This negative effect on the use of an extension program may be due to the fact that those who are more educated feel as if an agricultural extension program may be less beneficial to them. In terms of magnitude the estimates find that a one year increase in education increases the likelihood of adopting improved seeds by 0.061% which is small even

Table 4.3: Second Stage Estimates

	Improved Seeds (%)	Fertilizer (%)	Extension (%)	Prevent (%)	Irrigated (%)
	(1)	(2)	(3)	(4)	(5)
Education	0.061**	0.719***	-0.646***	0.557***	0.068**
	(0.031)	(0.073)	(0.054)	(0.055)	(0.028)
Constant	4.386***	49.673***	18.486***	14.798***	3.811***
	(0.103)	(0.249)	(0.193)	(0.178)	(0.095)

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.10$

though only 4.6% of all observations used improved seeds. The initial OLS of education on improved seeds (column (1) of Table 4.1) finds that a one year increase in education increases the likelihood of adopting improved seeds by 0.225%. This nearly four times as large as the 2SLS estimate suggesting that there is bias in estimating the effects of education on improved seeds. The effect of education on fertilizer and preventative measures actually increased from the initial OLS while irrigation remained about the same.

4.3 Instrument Validity

The First Stage regression in Table 4.2 reveals that distance from primary and secondary schools satisfy the instrument relevance requirement which is necessary to use an IV regression. Now I will check the next two requirements: exogeneity and the exclusion restriction.

Distance from school is exogenous if it is uncorrelated with characteristics of the observations in the data set. In other words it should be "as good as randomly assigned". I will check this by regressing distance from schools on characteristics of the the field decision makers that is located in Table 4.4. Specifically I look at a variable for age and indicator variables for gender, Orthodox, and married. The only estimates that are statistically significant are the effect of distance from secondary school on age and Orthodox as well as the effect of distance from primary school on being male. Each of these effects are negative suggesting that those who live further away from schools are younger, less likely to be male and less likely to be Orthodox. These estimates are small for the most part but they may disrupt the IV regression. Overall it appears that there is some evidence for distance from school being more or less exogenous.

Table 4.4: Regression for Exogeneity

	Age	Male (%)	Orthodox (%)	Married (%)
	(1)	(2)	(3)	(4)
Primary School (km)	-0.012	-0.110**	0.101	0.001
	(0.020)	(0.043)	(0.064)	(0.041)
Secondary School (km)	-0.051***	-0.004	-0.037**	-0.002
	(0.006)	(0.012)	(0.016)	(0.012)

Note: *** p<0.01, ** p<0.05, * p<0.10

Next I check the exclusion restriction. The exclusion restriction is satisfied if distance from schools only affects the adoption of agricultural technologies by affecting education. It is quite likely that being closer to schools means that one is closer to an urban area which may influence the adoption of agricultural technologies through means such as it being easier to procure technologies such as seeds and fertilizers. I regress distance from schools on distance from microfinance institutions, banks, urban centers, and towns in Table 4.5. There is a strong positive correlation between distance from schools and distance from other institutions which may be bad news for the exclusion restriction.

Table 4.5: Distance from School on Distance from Other Institutions

	Microfinance (km)	Bank (km)	Urban Center (km)	Town (km)
	(1)	(2)	(3)	(4)
Primary School (km)	0.019	0.287***	0.822***	0.221***
	(0.044)	(0.035)	(0.103)	(0.023)
Secondary School (km)	0.598***	0.604***	0.977***	0.780***
	(0.012)	(0.013)	(0.043)	(0.017)
Observations	16388	21012	67610	20824

Note: *** p<0.01, ** p<0.05, * p<0.10

Now I can check to see if these institutions do have an effect on the adoption of technologies by running an OLS of these variables on the adoption of agricultural technologies which is in Table 4.6. These institutions do appear to be significant in explaining the agricultural technologies which is problematic for the exclusion restriction, although there are a few things to consider. First of all these variables have many missing values which may skew the results, for example only about 22% of observations in the data contain information about distance from a microfinance institution. Furthermore many of these effects have a positive effect on education which would mean that being further away from these institutions actually increases the likelihood of adopting the agricultural technology which is unexpected. More investigation into whether or not the exclusion restriction is satisfied needs to be done.

5 Heterogeneous Effects of Education

Now I examine if the effect of education is heterogeneous across different crops. I allow

Table 4.6: Distance from Intuitions on Adoption of Agricultural Technology

	Improved (%)	Fertilizer (%)	Extension (%)	Prevent (%)	Irrigated (%)
	(1)	(2)	(3)	(4)	(5)
Microfinance (km)	0.012	0.097**	0.142***	0.312***	0.206***
	(0.018)	(0.049)	(0.028)	(0.034)	(0.025)
Bank (km)	0.047***	0.096***	-0.091***	0.285***	-0.049***
	(0.014)	(0.026)	(0.018)	(0.021)	(0.010)
Urban Center (km)	0.015***	0.010	0.008*	-0.052***	-0.020***
	(0.003)	(0.008)	(0.005)	(0.006)	(0.004)
Town (km)	-0.009	0.014	-0.141***	-0.284***	-0.027**
	(0.011)	(0.035)	(0.026)	(0.024)	(0.013)
Primary School (km)	0.247**	0.523**	0.498***	-2.316***	-0.880***
	(0.098)	(0.208)	(0.143)	(0.171)	(0.069)
Secondary School (km)	-0.199***	-0.538***	-0.239***	-0.048	0.171***
	(0.022)	(0.049)	(0.034)	(0.037)	(0.023)
Constant	8.756***	74.583***	61.576***	74.680***	10.395***
	(2.105)	(4.950)	(3.614)	(3.432)	(1.885)
Observations	15222	15067	15048	15201	14993

Note: *** p<0.01, ** p<0.05, * p<0.10

education to differ depending on whether or not the crop is a major staple crop. The major staple crops in Ethiopia include the following cereals: wheat, teff, millet, maize, barley, and sorghum [6]. About 46% of the observations in the data are a major staple crop. In order to account for heterogeneity the estimating equations need to be changed to include an interaction term with cash crops. The new estimating equations are:

$$T_{tvf} = \beta_1 E_{tvf} + \beta_2 (E_{tvf} \times I_{tvf}) + \mathbf{X}_{tvf}\Gamma + \alpha_t + \alpha_v + \varepsilon_{tvf} \tag{3}$$

$$\begin{aligned} E_{tvf} = {} & z_1 P_{tvf} + z_2 (P_{tvf} \times I_{tvf}) + z_3 S_{tvf} + z_4 (S_{tvf} \times I_{tvf}) + z_5 I_{tvf} \\ & + \mathbf{X}_{tvf}\Gamma + \alpha_t + \alpha_v + \nu_{tvf} \end{aligned} \tag{4}$$

These new first and second stage regressions are the same as equations (1) and (2) except that these equations contain the indicator I_{tvf}, which indicates if a crop is a staple crop, and interactions with it. $\mathbf{X}_{tvf}$ also includes interactions of the covariates. The 2SLS estimates are included in Table 5.1. The interaction terms are statistically significant from zero which indicates that there are heterogeneous effects of education between staple crops and non staple crops. The interaction term of education and staple crops is positive and large for all agricultural technologies except for irrigation which is negative. For staple crops the total effect of education (that is Education + Education × Staple Crop) is positive for all agricultural technologies except for irrigated which is insignificant. An interesting thing to note is that for non staple crops the effect of education on the use of technology is large and negative for all technologies except irrigation which is positive. More work should be done to look into more heterogeneity of more nuanced categories than just major staple crops.

Table 5.1: Heterogeneity Effects

	Improved (%)	Fertilizer (%)	Extension (%)	Prevent (%)	Irrigated (%)
	(1)	(2)	(3)	(4)	(5)
Education	-0.433***	-0.212**	-2.037***	-0.858***	0.115***
	(0.028)	(0.084)	(0.051)	(0.054)	(0.034)
Education	1.374***	2.569***	3.861***	3.982***	-0.118***
× Staple Crop	(0.056)	(0.116)	(0.092)	(0.096)	(0.044)

Note: *** p<0.01, ** p<0.05, * p<0.10

6 Conclusion

Agricultural technology can be used to increase the productivity of farmers which can increase economic growth, especially in developing countries with large agricultural sectors. However, factors that affect the adoption of these technologies such as education are not well understood.

This paper shows that overall there is a positive relationship between education and the adoption agricultural technologies such as the use of improved seeds, fertilizer, preventative measures, and irrigation. However, there is also find a negative effect of education on the use of extension programs.

Looking into heterogeneous effects on crops reveals that for non staple crops the effect of education is negative for all agricultural technologies except irrigation. I am not quite sure as to why this is the case although it is possible that some agricultural technologies are not as cost effective for the non staple crops which would could potentially lead those who are more educated to make the decision not to use them. For the staple crops there are large effects of education on the adoption of improved seeds, fertilizer, extension programs, and preventative measures, although the effect on irrigation is negligible.

My estimates suggest that for those who grow staple crops that increasing education by 5 years could increase adoption of improved seeds by about 4.7%. Considering that 8% of staple crops observations used improved seeds in the data set, increasing education by 5 years is estimated to increase the adoption of improved seeds by over 50%. The mean years of education in the data set was 2 years so there is certainly room for education to increase. This suggests that policies that promote education could be an effective way of increasing the adoption of agricultural technologies, among staple crops at least.

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A Appendix

Table A.1: Level of Education to Years of Education

Highest Grade Completed	Education in Years
Based on Both Curriculums	
Kindergarten	1
1st Grade	2
2nd Grade	3
3rd Grade	4
4th Grade	5
5th Grade	6
6th Grade	7
7th Grade	8
8th Grade	9
9th Grade	10
10th Grade	11
11th Grade	12
12th Grade	13
1st Year College	14
2nd Year College	15
Diploma	15
3rd Year College	16
Bachelors	17
Postgraduate Diploma	19
Based on Previous Curriculum	
12th Grade +1 (Certificate)	14
Teacher Training Certificate	14
Based on New Curriculum	
Certificate (10+1) Vocational Course	12
Level 2 Vocational Course	13
Certificate (10+2) Vocational Course	13
1 Year in 10+3 Course	12
2 Years in 10+3 Course	13
Diploma in 10+3 Course	14
Everything Else	0

Note: Ethiopian Education Information from [7]