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The complementarity of education and use of productive inputs among smallholder farmers in Africa

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Abstract

This study seeks to assess the complementarity of education and use of use of agricultural inputs–improved seeds, fertilizers, access to credit facilities), and the incremental effects of education on intermediate to longer-term economic outcomes (consumption expenditure and poverty) among smallholder farmers in four countries in SSA Africa (Ethiopia, Malawi, Nigeria and Tanzania). We apply a multinomial endogenous treatment model with education as our 'treatment' variable with four possible levels (no-schooling, primary, secondary, post-secondary). The empirical model jointly estimates treatment and selection effects and by this corrects for selection into one or the other education level. Using nationally representative LSMS panel data allows us to comprehensively assess the impact of education on the outcome variables. Overall results suggest that higher education (secondary and post-secondary level) significantly increases the use of improved seed varieties and fertilizers, access to credit services, and per capita consumption expenditure and consequently reduces household poverty. Specifically, findings suggests that post primary education (secondary and post-secondary levels) is by far the most important factor in use of productive inputs than mere introductory literacy and primary learning. These findings augment the conclusion that schooling have positive impacts for the farmers and their households' well-being. Our findings are of policy relevance to most SSA countries currently grappling with rising urbanization, high youth unemployment, and acute skills shortage.

Keywords: skill development, education, vocational training, smallholder farmers, poverty, Sub-Saharan Africa, PARI

1. Introduction

It is widely recognized by development scholars and practitioners that human capital and skill development are significant determinants that could positively affect farmers' performance and their disposition to adopt innovations (Ghadim & Pannell, 1999; FAO, 2007; Mavunganidze et al., 2013; Abay et al., 2016; Okello et al., 2017). More than 70 per cent of the poor people in Africa live in rural areas and engage on smallholder agriculture for food and livelihood (FAO 2014). Besides employing a vast majority of the population, smallholder agriculture generates about 32% of gross domestic products (GDP). In some of the SSA African countries, agriculture contributes up to 80% of trade in value and more than 50% of raw materials to industries (Staatz and Dembele 2007; Anon, 2015). Yet majority of these smallholders are poor, have very low levels of education, and are faced with precarious food and nutritional insecurity. Their capacity to innovate or adopt new technology through investment in education, training and skill development would be necessary to lift them out of poverty while assuring food and nutritional security, and environmental sustainability.

Education (general, as well as specific agricultural education and training), is argued as vital ingredient to overcoming development challenges in rural areas (Moulton, 2001; FAO, 2007; Biriescu and Babaita, 2014). More specifically, education is recognized to impact on agricultural productivity by improving the quality of labor (Limbu 1999; Chirwa, 2005; Mavunganidze et al., 2013; Abro et al., 2014; Ali et al., 2016; Hicks et al., 2017; Feder and Savastano, 2017). Furthermore, education plays an important role in aiding the adoption of natural resource management technologies (Deressa et al., 2010; Chen & Sintov, 2016; Wainaina et al., 2016; Mponela et al., 2016; Gruber et al., 2017; Koppmair et al., 2017) and adaptation to climate change (Spittlehouse, 2003; Maddison, 2007; Deressa et al., 2009; Belay et al., 2017; Hemstock et al., 2017). Schooling is thought to empower farmers to become dynamic partners in development rather than passive beneficiaries (Dixon et al., 2001).

Education is also thought to be essential in face of a rapidly changing technological environment (Shultz 1975). The African agriculture is faced with an increase in use of technological innovations such as high yielding seed varieties, chemical fertilizers, irrigation technologies, pests and disease control options, climate change adaptation and mitigation options, and use of modern ICTs (such as mobile phones and internet). Indeed the mobile phones and internet access can help farmers acquire and share new information (market price information, weather information, extension advisory service) in a quick and cost-effective manner (Aker, 2008; Kirui et al., 2013; Aker and Ksoll, 2015; Baumüller, 2016).

The recent World Bank's flagship publication–World Development Report (WDR)–confers that a properly structured and well delivered education is beneficial for both the individual and society. For individuals, it promotes employment, earnings, health, and poverty reduction. While it spurs innovation, strengthens institutions, and fosters social cohesion for society (WDR, 2018). High-quality basic education for children ought to be followed by expansion of high-quality secondary and tertiary opportunities so as to reap greater benefits of education. In other words, foundational skills and universal primary education is necessary but not sufficient to drive growth and development of nations. Several studies have established that as countries approach the global technological frontier, they need to invest more in higher education and in research and development (Aghion and Howitt, 2006).

Enrollment in formal schooling is driven by the accompanying potential economic benefits of finding paid employment or the potential to generate income through self-employment while utilizing skills acquired while in school. On one hand, access to appropriate basic formal primary and secondary education can provide numeracy, literacy, managerial, and business skills to farmers, and introduce youth to agriculture. Thus, households would earn income both in cash and in kind from farming and off-farm activities, wage employment, and remittances from migrants. However, number of years in school does not necessarily translate into cognitive attainment (ILO 2009, 2012). On the other hand, vocational education, training (non-formal and informal), and tertiary agricultural education can provide more specific knowledge related

to agriculture. Training offered at various vocational agricultural training institutions may require that applicants have an appropriate background in formal education to be efficient and effective learning (Morton, 2007; Harvey et al., 2014). Yet African educational systems have been criticized for neglect of vocational and technical training needed for transformation of both agricultural and manufacturing sectors (see a review by Kirui and Kozicka, 2017).

In many developing countries, access to as well as the quality of education is often worse in rural areas as compared to urban areas. The limited learning infrastructure and classroom materials and fewer teachers characterize rural education landscape in many countries. Poverty and food insecurity, and schools located far away from communities further hamper school attendance (FAO, 2009). Furthermore, only 2 percent of university students in sub-Saharan Africa are enrolled in agricultural studies (MIJARC/IFAD/FAO, 2012). This is was too low for agriculturally based economies.

The assessment of the impact of education (and especially post-primary level of education and vocational training) on households' economic outcomes such as incomes, expenditures and poverty is largely missing partly due to unavailability of data. This study uses education attainment among household heads whose main occupation is farming using comprehensive nationally representative data for four countries in SSA Africa (Ethiopia, Malawi, Nigeria and Tanzania). We hypothesize that farmers with higher level of education are more knowledgeable on improved farming techniques and thus likely to adopt technology and innovations more rapidly. This would in turn translate to higher incomes, consumption expenditure and reduced poverty. This study seeks to assess the impact of education on several outcomes such as use of agricultural inputs–improved seeds, fertilizers, access to credit facilities (loans), consumption expenditure, and poverty among smallholder farm households in Ethiopia, Malawi, Nigeria and Tanzania.

The rest of this paper is organized as follows: Section 2 surveys the literature on the importance of schooling in agriculture (technology and innovation adoption) and on poverty. The organization and salient features of the education systems in the four selected countries is described in section 3. Section 4 outlines the empirical methodology. Results are presented in Section 5. Section 6 concludes the paper with a summary of the main findings and the implications.

2. Relevant literature

Several studies have underscored the importance of education and training in enhancing sustainable land management (Mirzabaev, Nkonya & von Braun, 2015; Kirui & Mirzabaev, 2014; Kirui, 2016); soil and water conservation (Haggblade and Tembo 2003; Fernandez-Cornejo et al., 2005; Anley et al. 2007); and on natural resource management (Fuglie and Kascak 2001; Marenya and Barret 2007; Abdulai and Huffman 2014). Farmers' level of education stimulates adoption and intensity of fertilizer use in Uganda (Diiro and Sam 2015), Niger (Abdoulaye and Sanders, 2003), Malawi (Chirwa, 2005), and Kenyan (Freeman & Omiti, 2003). Education also improved adoption of maize technologies (fertilizer and hybrid seed) in Kenya and Zambia (Jayne et al., 2006; Olwande et al., 2009), intensity of adoption of conservation agriculture by smallholder farmers in Zimbabwe (Pedzisa et al., 2015). Studies show that low level of education constraints adaptation to climate change both in crop farming (Belay et al., 2017) and livestock farming (IPCC, 2007; Deressa and Hassan, 2010; Belay et al., 2017).

Several other studies in different developing countries have shown that high illiteracy rates hinder farmers' understanding of pesticide use and safety instructions: Ibitayo (2006) in Egypt; Kimani and Mwabthi (1995) in Kenya; Stadlinger et al. (2011) in Tanzania; Dasgupta et al., (2007) in Bangladesh; Hashemi et al. (2012) in Iran and (Karunamoorthi et al. 2011) in Ethiopia. Higher levels of illiteracy and lack of financial resources is believed to limit access to and use of technologies and innovations among farmers in developing countries (World Bank, 2011). Education and literacy enables farmers to access information, expand their knowledge regarding production technology and market opportunities, thus, allowing them to make better decisions.

Studies have shown that farmers with just a few years of basic schooling are more likely to adopt and correctly apply agricultural innovations (Närman, 1991, Suvedi, Ghimire, Kaplowitz, 2017).

Though many studies find positive impact of education on farmers' performance, a few have found no significant effect (such as reviews by Wei (1999) and Reimers and Klasen (2013). The mixed evidence of the impact of education may be explained by two factors. Firstly, the dependence of the actual educational outcomes on additional factors within the education system (such as the quality of education) and factors beyond the education system (such as the social, cultural economic and political environments), and secondly, the improper specification of the education variable in the empirical studies (Reimers and Klasen, 2013).

The effect of education on poverty and income has received extensive attention by economic researchers. The linkages between education and poverty has been proven to be significant in many instances using different metrics and proxies for both education and poverty (Berg, 2008; Janjua and Kamal, 2011; De Silva and Sumarto, 2015). A study by De Silva and Sumarto (2015) found that increased education capital would lower level of poverty within districts in Indonesia. Janjua and Kamal (2011) found that both secondary education and income per capita growth were significant factors in alleviating poverty, however, secondary education was by far the most important factor. Berg (2008) found that the impact of education on poverty may be linear or more intricate in which better education leading to better farming methods, which lead to higher crop yields and a greater income, reducing the probability that a farmer poor. This can be achieved through various mechanisms, namely: (i) higher levels of education may lead to higher earnings, (ii) higher and better quality levels of education might increases economic opportunities; and (iii) higher levels of education might lead to higher social benefits (ibid).

In addition to formal basic and secondary education, apprenticeships, vocational training, and extension services are effective avenues for teaching agricultural skills and providing capacity building trainings for farmers (Bennell, 2007). Apprenticeships are a common way to combine classroom with workplace learning. Formal apprentice and vocational training programs may last from six months to three years and take place at the lower secondary, upper secondary or postsecondary level or as an alternative to upper secondary education, giving students the opportunity to engage in industry-supervised workplace practices (Tan and Nam, 2012; OECD, 2014; Fazio and Ripani, 2016). Apprenticeship programs at secondary or post-secondary level should build on foundational skills, as well as occupation-specific skills, to avoid overly narrow specialization (OECD, 2010). Apprentices who earn while learning are typically paid less than the market wages (Biavaschi et al., 2012; Smith and Kemmis, 2013). However, upon graduation, Technical, Vocational Education and Training (TVET) can yield wages on par with equivalent levels of general education.

The rather weak state of agricultural vocational education and training in Africa is characterized by many limitations. They include but are not limited to: the marginal attention it receives; the lack of a strong network involving all stakeholders from the agricultural sector (farmers, trainers, public and private actors); the lack of resources dedicated to it; and the negative perception of professions and employment prospects upon completion of training (see Kirui and Kozicka (2017) for detailed review). The low levels of formal education further limit training possibilities among many youth and farmers (IFAD, 2010).

A well-structured apprenticeships would offer structured training, professional trainer(s), a contract that stipulates training arrangements, and an assessment to verify acquired skills (Cumsille 2016; Fazio, Fernández-Coto and Ripani, 2016; Smith and Kemmis, 2013). With a proper partnership between the education system and industry is possible to integrate firm resources, share risk burdens, develop industry-wide skill standards, and deliver apprenticeship training at scale (WDR, 2018).

Studies show positive results for both firms and the individuals who complete formal apprenticeships (Dietrich, Pfeifer, and Wenzelmann, 2016; Hollenbeck, 2008; Lerman, 2014; Smith and Kemmis, 2013). Hollenbeck (2008) showed positive gains from secondary TVET, postsecondary TVET, and apprenticeship

programs in United States (Virginia and Washington states) found from all three—especially apprenticeships. Lerman (2013; 2014) find that employers in Canada, Germany, Switzerland, and United States recover initial apprentice costs in the short to medium term. Corseuil et al (2014) show that graduates of a large formal apprenticeship program (Lei do Aprendiz) in Brazil are more likely to find permanent, higher-paying jobs, with larger gains for less educated workers. Safford et al. (2013) show that graduates from an innovative formal apprenticeship program in Malawi targeting young women seeking to work as schoolteacher gained higher skills and community standing.

While looking at the education system, one has to also consider the broader economic, political, and social institutions that have a bearing on it. For example, low demand for educated labour reduces the return to skills (WDR, 2018). The interplay between demand and supply forces in the labour market determines returns to education (Pritchett, 2001). If the demand for educated labour is low relative to supply, then the returns to education will be low or declining (ibid). Many educated youth in several places of the developing world queue for jobs in already large public sectors. In several countries, political aspirants compete in terms of their ability to offer patronage and/or public employment to their supporters (Cammett, 2009; Kao, 2012; Lust-Okar, 2009 cited in WDR, 2018).

Inherent weakness in the education system in many developing countries is pronounced. For example, it is estimated that about 37 million children in African will learn so little in school that they will not be much better off than kids who never attend school (van Fleet 2012). Hungi et al (2010) found that about 27% of 12-year-olds enrolled in grade 6 in South Africa (and 44% in Zambia) were functionally illiterate. Furthermore, many young people leave formal education with weak foundational skills, and thus they are unprepared for further education and training (WDR, 2018).

Data from Lee & Lee (2016) show that globally, about 61 percent of the students entering primary education will complete lower secondary education, and just about 35 percent will complete upper secondary (UNESCO 2015, WIDE 2017). Majority of these children will be in developing countries as illustrated in Figure 1. This implies that about a third of youth leave school between lower and upper secondary–this is especially more pronounced in several developing countries, where sizable shares of these young people (aged 15- to 24-years) score below the minimum level of literacy proficiency (WDR, 2018).

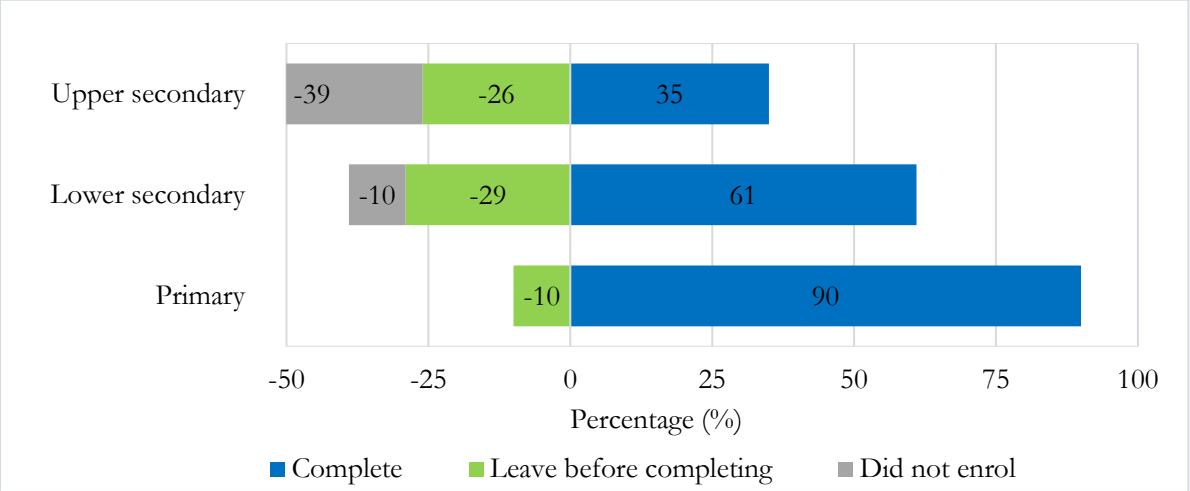

Figure 1: Completion and attrition rates (percent) at the global level
Source: Adapted from WDR (2018), using data from UIS, 2017; UNESCO, 2015; WIDE, 2017)[1].

[1] Data available at: http://bit.do/WDR2018-Fig_5-6

Indeed the biggest proportion of those with less than a primary education is in SSA and South Asia, but the proportion of those with primary education or less is the highest (66%) in SSA as compared to South Asia (50%) and Middle East and North Africa (46%) as illustrated in Figure 2. Subsequently, as illustrated in Figure 3, a vast majority of young people in SSA (77%) will not complete upper secondary school level compared to South Asia (68%), Middle East and North Africa (58%) and Latin American and the Caribbean (58%).

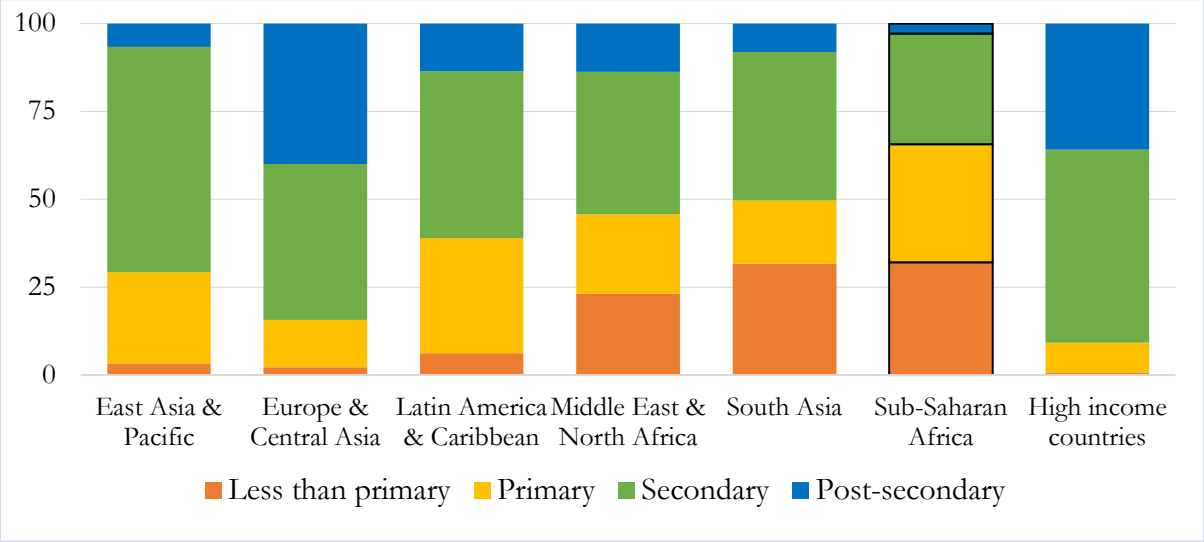

Figure 2: Stock of educational attainment (in %) (ages 15–64) in 2010 by region
Source: Adapted from WDR (2018), using data from Lee & Lee, 2016[2].

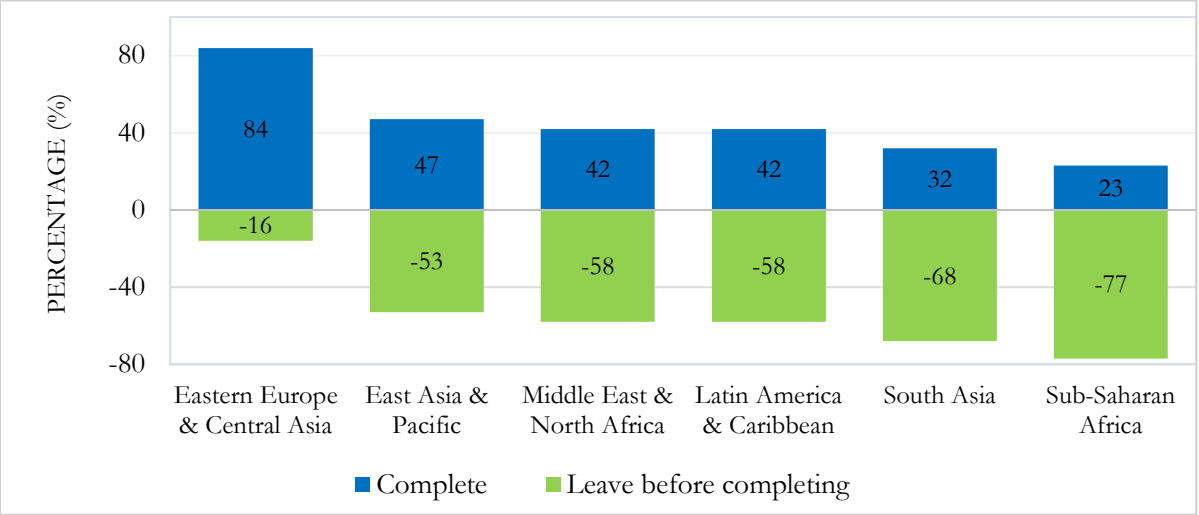

Figure 3: Completion and attrition rates at upper secondary school level by region
Source: Adapted from WDR (2018), using data from UIS, 2017; UNESCO, 2015; WIDE, 2017)[3].

A poor-quality basic education also means that learners who should be gaining advanced skills from secondary and post-secondary (tertiary) education or technical training lack the preparation to do so. It is

[2] Data available at: http://bit.do/WDR2018-Fig_2-2
[3] Data available at: http://bit.do/WDR2018-Fig_5-6

noteworthy that improving foundational education and skills early provides an opportunity to alter workers' labor market trajectories. Several studies ((Zachry & Schneider, 2010; Almeida et al., 2006; NCES, 2004; de Hoyos, et al, 2016 all cited in WDR, 2018) argue that youth vary greatly in skills and maturity, putting them on a range of different pathways:

i. Some young school leavers enrol in second-chance programs seeking to obtain formal education equivalency diplomas so they can gain access to further education/training (Zachry & Schneider, 2010).
ii. Some pursue remedial coursework to fulfil admission requirements for postsecondary education or training institutions (Almeida et al., 2006; NCES, 2004).
iii. Some others — usually those with the most serious skills gaps—go into unstable, low-wage, low-productivity jobs, while some youth remain out of both school and the labour force (de Hoyos, et al, 2016).

3. Methods

3.1. Data

This study utilizes farming household panel survey data of two waves (first and the most recent) of Ethiopia Rural Socio-economics Survey (ERSS), Nigeria General Household Survey (GHS), Malawi Integrated Household Panel Survey (IHPS), and Tanzania National Panel Survey (TNPS). These panel surveys are supported by the Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA) project undertaken by the Development Research Group at the World Bank. The project aims to support governments in Sub-Saharan African countries to generate nationally representative, household panel data with a strong focus on agriculture and rural development. LSMS-ISA supports multiple rounds of a nationally representative panel survey with a multi-topic approach designed to improve the understanding of the links between agriculture, socioeconomic status, and non-farm income activities. The surveys are widely available and provide a rich source of information at the household level on sources of income and expenditures as well as agriculture (World Bank, 2015).

The panel surveys were based on the two-stage stratified random sampling procedure. In the first stage, the enumeration area (EA) stratified according to spatial location were the principal sampling unit, and the selections of EAs, was based on the latest national census as the frame. In the second stage, 10 households were randomly selected from each of the EAs. The agricultural module provided information including: household land holdings; type and quality of soils used for cultivation; investments on land; types of crops produced, and the use of improved seeds; the use of organic and chemical fertilizers; agricultural labor inputs; and access to extension services, use of fertilizers and improved varieties, among others. The total sample size for each country is thus different as described below.

Ethiopia: The Ethiopia Rural Socio-economics Survey (ERSS) is a panel survey is implemented by the Central Statistical Agency of Ethiopia (CSA), and is integrated with the annual Agricultural Sample Survey (AgSS). The ESS is implemented every two years. The sample for the ERSS (Wave 1) comprises 4,000 households were visited in 2011/2012 in rural and small towns across Ethiopia. The sample for ESS (Wave 2 and Wave 3) was expanded to include 1,500 urban households, for a total sample of 5,500 households and were visited in 2013/2014, and then re-visited again in 2015/2016.

Malawi: The Malawi Integrated Household Survey (IHS) Program started with the implementation of the Third Integrated Household Survey (IHS3) in 2010/11. Following up on the IHS3, the Integrated Household Panel Survey (IHPS) 2013 was implemented to track and re-interview 3,246 households that were previously interviewed during the IHS3. The IHPS also tracked split-off individuals that moved away from IHS3 dwelling locations to establish/join new households, which were in turn interviewed by the IHPS, boosting the panel household sample to 4,000 in 2013.

Nigeria: The Nigeria General Household Survey (GHS) was expanded to introduction of a panel component that focuses on agriculture and household welfare. The GHS is an annual survey carried out in February-March throughout the country on a sample of 22,000 households to produce state level estimates. The panel component is implemented every two years. The project also ensures comparability with other surveys being carried out under the LSMS-ISA project in in Sub-Saharan Africa. The Nigeria National Bureau of Statistics (NBS) implements the GHS-Panel. The GHS-Panel sample consists of 5,000 households- a subsample drawn from the GHS core survey of 22,000 households.

Tanzania: The Tanzania National Bureau of Statistics (NBS) implements TZNPS. The TZNPS sample for the first round was 3,265 households while the sample size for the second round subsequently expanded to 3,924. The third round adhered to the same tracking protocol as the second round resulting in a final sample size of 4,015 households.

The scope of this study is to assess the impact of education on economic outcomes only for smallholder farmers. Thus, from the whole LSMS sample we focus only on a sub-sample of households engaged primarily in agricultural production (i.e. households that derive their livelihoods from agriculture). A summary of the number considered in this study is presented in Table 1. This constitute 3397, 2924, 3138, and 2361 (or 62%, 73%, 63%, and 59% of the sampled households in Ethiopia, Malawi, Nigeria, and Tanzania respectively.

Table 1: Summary of sub-sample relevant for current study

Variable	*Ethiopia*	*Malawi*	*Nigeria*	*Tanzania*
LSMS-ISA Panel Survey	5,500	4,000	5,000	4,015
Agricultural households (N)	3397	2924	3138	2361
Agricultural households (%)	61.8	73.1	62.8	58.8

Source: author's compilation.

3.2 Empirical framework and estimation technique

Economic literature suggests several conceptual and theoretical models on farmers' decisions to adopt new technology (Feder and Slade, 1984; Abadi Ghadim and Pannell, 1999; Isham, 2002) – a detailed review of these frameworks are presented in Negatu and Parikh (1999). The review suggests three groups of models underpinning adoption of agricultural technologies and innovations by smallholder farmers: innovation–diffusion or transfer of technology models, the economic constraint models, and the technology characteristics–user's context models. The transfer of technology model suggests the importance of an intermediary (such as agricultural extension agents and services) in the process of transfer of technologies from the source to the smallholder farmer. They postulates that that the availability and the distribution of different intermediaries determines the adoption of technology among smallholder farmers. The technology characteristics–user's model hypothesizes that technology-specific factors (such as cost, ease of use) as well as farmer-specific factors (such as socio-economic, cultural, and institutional factors) have a significant effect on the adoption and diffusion of the technologies.

Earlier work by Feder and Slade (1984) establishes a model of technology adoption and diffusion based on human capital and land constraints. Their model postulates that farmers with more education and bigger sizes of farmland would be more knowledgeable on improved farming techniques and thus likely to adopt technology more rapidly. By extending Feder and Slade (1984) model, Abadi Ghadim and Pannell (1999) the role of learning by doing on personal perceptions and adoption of the innovation.

As previously indicated, this paper seeks to examine the effect of education on use of agricultural inputs (improved seeds, fertilizers), credit facilities (loans), household consumption expenditure and poverty. Unlike previous studies (see section 2) that try to highlight the importance of education measured either by literate or not, or in terms of years of schooling, this study, while controlling for the other different levels of education, seeks to identify incremental effects of higher (post-secondary) education. Our primary outcome variables are whether or not the household used of improved seed varieties, fertilizers, accessed to credit (loans), and the value of household consumption expenditure and poverty (indicators of farmer welfare). Use of improved seed varieties or fertilizer is measured as a dummy variable (1=use, 0=otherwise). Access to credit is also measured as dummy variable (1=access, 0=otherwise). The consumption expenditure is measured as aggregate expenditure on food and basic non- expenditure. Per capita consumption expenditure is the aggregate consumption expenditure divided by household size (adult equivalent). A household is considered poor if the per capita consumption expenditure is less than the nationally defined poverty line (minimum cost of food and basic no-food items spatially and temporal adjusted).

In order to achieve the objectives of this study, we need to account for the potential endogeneity of education and our outcome variables due to self-selection (selectivity bias) and simultaneity. Attaining a given level of education is not random because persons with higher endowments (such as innate ability) may be more likely to attend school. Some unobservable characteristics – such as ability and motivation – may affect post-secondary education and the outcomes of interest simultaneously. Failure to account for these issues may lead to biased estimates. To address the problems of endogeneity and given the multinomial (ordinal) nature of the 'treatment' variable (education level), we use the multinomial treatment effects model suggested by Deb and Trivedi (2006a, 2006b). Multinomial treatment effects model allows for the estimation of the effects of an endogenous multinomial 'treatment' variable on binary, count or continuous outcomes, while accounting for selectivity bias.

Following Deb and Trivedi (2006a), we assume that farmers' level of education follows a mixed multinomial distribution, and thus the probability of observing the ith farmer attain education level j can be expressed as:

$$Pr(v_{ij} = 1 | z_i, l_{ij}) = \frac{\exp(z_i'\psi_j + \phi_j l_{ij})}{\sum_{k=0}^{J} \exp(z_i'\psi_j + \phi_j l_{ij})} \quad (1)$$

where v_{ij} is the j^{th} level of education attainment ($v_{ij} = v_{i0}, v_{i1}, v_{i2}, v_{i3}$)corresponding to no education, primary level, secondary level, and post-secondary level respectively; z_i denotes exogenous covariates with respective parameters ψ_j; ψ_j contains unobservable characteristics common to the i farm household status of post-secondary j and outcomes, and ϕ_j are factor loading parameters associated with l_{ij}; l_{ij} are factors influence both the level of education and the outcome variables; μ_{ij} is an error term that is assumed to be independent and identically distributed (iid).

The outcome equation is be specified as:

$$E(y_i^*) = X_i'\beta + \delta_1 v_{i1} + \delta_2 v_{i2} + \delta_3 v_{i3} + \sum_{j} \lambda_j l_{ij} + \varepsilon_i \quad (2)$$

where y_i^* is the latent variable underlying the observed outcome variables (i.e. use of improved seeds, use of fertilizer, credit access, household consumption expenditure and poverty); X_i is a set of control variables (including demographic, socioeconomic, institutional, biophysical, and regional characteristics with the associated parameters β); v_{i1}, v_{i2}, v_{i3} are dummy variables denoting primary level, secondary level, and post-secondary level of education relative to the base category (no education) respectively and $\delta_1, \delta_2, \delta_3$ are the respective parameters which are our main parameters of interest; l_i are the latent factors, capturing the unobserved factors that influence both level of education attained and the outcome variables; λ are

coefficients associated with unobservable characteristics and can be interpreted in terms of selection effects. For instance, λ >0 indicates favorable selection, implying that unobserved factors that induce an individual to pursue education are associated with positive performance outcomes. Similarly, $\lambda < 0$ suggests negative selection; while $\varepsilon_i$is an iid error term.

Conditional on the common unobserved factors, the joint distribution of selection and outcome variables can be specified as:

$$\Pr(Y_i = y_i, v_{ij} = 1 | X_i, Z_i, l_{ij}) = f\left(X_i'\beta + \delta_1 v_{i1} + \delta_2 v_{i2} + \delta_3 v_{i3} + \sum_{j=1}^{3} \lambda_j l_{ij}\right) X\, g\left(Z_i'\psi_j + \lambda_j l_{ij}\right) \quad (3)$$

The parameters of equation (3) which is the multinomial endogenous treatment effect model are estimated using the maximum simulated likelihood procedure as proposed by Deb and Trivedi (2006) in Stata.

The explanatory variables (control and instruments) included in the Equation 3 ($\boldsymbol{X}$ and $\boldsymbol{Z}$) are motivated by literature on adoption of agricultural technologies, natural resource management, and on the few studies that estimate the determinants of household consumption expenditure and poverty – as described in chapter 2 (review of relevant literature). The variables include household demographic characteristics (e.g. age, gender of the household head, household size), socioeconomic and institutional characteristics (farm size, livestock holding, access extension services, distance to market), as well as biophysical characteristics (e.g. temperature, rainfall, elevation, terrain and agro-ecological classification). Regional (region or district) dummies are also included for each of the countries.

Exogenous variation is exploited to improve identification by using variables in $\boldsymbol{Z}$ that influence the choice of treatment but apart from that do not have direct effects or correlations with unobserved factors. Previous studies have applied Instrumental Variables (IV) as a standard solution to the schooling and the ability bias problem. Previous researchers have chosen compulsory school laws (Angrist and Krueger, 1990), twins (Ashenfelter and Krueger, 1992), proximity of education institution (Card, 1993; Card, 2001; Zhang and Matz, 2017), and parental education (Altonji and Dunn, 1996; Maluccio, 1998; Holmlund et al, 2016; Havari and Savegnago, 2016) as instruments to estimate unbiased return to schooling. In this study we use the parents' level of education to instrument the level of education.

Parents' education level has been found to not only have a significant correlation to children's level of education but also to significantly impact on children's growth and development. Parents' financial ability and their level of education are some of the characteristics that may enhance their willingness to invest in their children's human capital and subsequently on efficacy of return to education (see Altonji and Dunn, 1996; Maluccio, 1998; Holmlund et al, 2016; Havari and Savegnago, 2016 for detailed descriptions). We do not believe parents' level of education to have an own effect on the outcome variables. At best one might be afraid that parents levels of education might influence the outcome through remittances, however, this should be captured by remittance dummy.

Table 2 presents detailed description of the outcome variables, the 'treatment' variable, and the other independent variables used in the regression.

Table 2: Description of variables used in regression models

Variable	Description
Outcome variables	
Improved seeds	Used improved seeds *((1=Yes, 0=Otherwise)*
Fertilizer use	Used fertilizer *((1=Yes, 0=Otherwise)*
Credit access	Access to credit services (loan) *(1=Yes, 0=No)*
Cons. Exp.	Annual household expenditure *(local currency)*
Log Cons. Exp.	Annual household per capita expenditure *(local currency)*
poor	Per capita expenditure is below the national poverty line *(1=Yes, 0=Otherwise)*
Independent Variables	
'Treatment variable'	
EDU_level	Highest level of education attained *(0=no schooling, 1=primary, 2=secondary, 3=post-secondary)*
Demographic characteristics	
age	Age of household head *(years)*
sex	sex of household head *(1=Male, 0=Otherwise)*
hhsize	Size of household *(adult equivalent)*
Housing characteristics	
impwall	Wall materials of the main house are improved *(1=Yes, 0=Otherwise)*
improof	Roofing materials of the main house are improved *(1=Yes, 0=Otherwise)*
imph20	Drinking water sources are improved *(1=Yes, 0=Otherwise)*
imptoil	the toilet used by household is improved *(1=Yes, 0=Otherwise)*
rooms	Total number of rooms excluding kitchen in the household *(number)*
Socio-economic characteristics	
farmsize	Size of the farm land *(Ha)*
remittances	Received remittances *(1=Yes, 0=Otherwise)*
mrktdist	Distance from home from the market *(km)*
disdist	Distance from plot from the market *(km)*
elect	The household has electricity *(1=Yes, 0=Otherwise)*
goats	Number of goats owned by the household *(number)*
cattle	Number of cattle owned by the household *(number)*
radio	The household has radio *(1=Yes, 0=Otherwise)*
bike	Number of bikes owned by the household *(number)*
tv	The household has TV *(1=Yes, 0=Otherwise)*
cellphones	Number of cell phones owned by the household *(number)*
tittledeed	Possess land title deed of plot *(1=Yes, 0=Otherwise)*
extension	Access to extension services *(1=Yes, 0=No)*
Biophysical characteristics	
temp	Annual Mean Temperature *(^0C*10)*
rain	Annual Mean Rainfall *(mm)*
elevation	Slope of the plot *(SRTM)*
Plateaus	Terrain *(1 = plateau, 0 = Otherwise)*
hills	Terrain *(1 = hills, 0 = Otherwise)*
mountains	Terrain *(1 = mountains, 0 = Otherwise)*
warm_arid	Agro ecological zone *(1 = warm arid, 0 = Otherwise)*
warm_semiarid	Agro ecological zone *(1 = warm semiarid, 0 = Otherwise)*
warm_humid	Agro ecological zone *(1 = warm humid, 0=Otherwise)*
warm_subhumid	Agro ecological zone *(1 = warm sub-humid, 0=Otherwise)*
cool_arid	Agro ecological zone *(1 = cool arid, 0 = Otherwise)*
cool_semiarid	Agro ecological zone *(1 = cool semiarid, 0 = Otherwise)*
cool_humid	Agro ecological zone *(1 = cool humid, 0 = Otherwise)*
cool_subhumid	Agro ecological zone *(1 = cool sub-humid, 0 = Otherwise)*
Regional dummies (district or region) are included for each country	

Source: author's compilation.

3.3 Descriptive statistics

3.3.1 Description of education level ('treatment' variable)

Table 3 describes the different levels of education attained by the household head (decision maker) in the four countries. The largest category of education group in Ethiopia, Malawi, and Tanzania is the illiterate group (66%, 73%, and 50% respectively). In Nigeria about 37% and 38% of the sampled household heads were illiterate and had completed primary level of education respectively. Only about 10% of the sampled households had attained secondary level of education in Ethiopia and Malawi as compared to 12% in Tanzania and 16% in Nigeria. Very few household heads had attained more than secondary level of education about 6% in Ethiopia, 7% in Malawi, 9% in Nigeria and 6% in Tanzania.

Table 3: Education level ('treatment' variable)

Country	Highest level of education completed			
	No school	Primary	Secondary	Post-Secondary
Ethiopia (n=6794)	4490 (66.1%)	1192 (17.5%)	723 (10.6%)	390 (5.7%)
Malawi (n=5848)	4264 (72.9%)	622 (10.6%)	530 (9.1%)	432 (7.4%)
Nigeria (n=6276)	2600 (37.1%)	2643 (37.7%)	1124 (16.0%)	642 (9.2%)
Tanzania (n=4722)	2346 (49.7%)	1520 (32.2%)	552 (11.7%)	304 (6.4%)

Source: author's compilation.

3.3.2 Relationship between level of education and outcome variables

Table 4 provides an overview of the output variables over the four levels of education. In general, about 18%, 26%, 14% and 17% of households in Ethiopia, Malawi, Nigeria, and Tanzania used improved seeds. In all the four countries, the proportion of users of improved seed increased with the level of education attained. In Ethiopia for example, only 13%, 14%, 24%, and 48% of the illiterate, primary level graduates, secondary level graduates, and post-secondary level graduates respectively used improved seeds. Similarly, these proportions were 19%, 19%, 27%, and 29% for illiterate, primary level graduates, secondary level graduates, and post-secondary level graduates respectively in Malawi. Access to credit for agricultural and/or for business purposes is very low across the four countries (6%, 7%, 3% and 4% in Ethiopia, Malawi, Nigeria, and Tanzania respectively). Similar to the use of improved seeds, access to credit increased with increased level of education. For example, only about 1% and 2% of the illiterate and the primary level graduates accessed credit services as compared to 8% and 12% of the secondary and the post-secondary graduates in Nigeria respectively. Similarly, only about 3% of those with no education or with primary level of education accessed credit services in Tanzania as compared to 11% and 13% of the secondary and post-secondary level graduates. The use of fertilizer was better than use of improved seeds and access to credit in all the four countries. About 56%, 42%, 41% and 18% of all the sampled households in Ethiopia, Malawi, Nigeria, and Tanzania used fertilizer in their farm plots.

Table 4 further shows that annual real per capita consumption expenditure (measured in local currency) was higher for higher levels of educated completed. For example, in Tanzania the per capita consumption expenditure was 597155, 623922, 801712, and 1107549 Tanzania shillings for the illiterate, primary level, secondary level and post-secondary level graduates respectively. Finally, the proportion of the poor was high among illiterates followed by those with primary level of education in all the four countries. This proportion was the least among secondary and post-secondary level graduates – as low as 14%, 16%, 19% and 17% for post-secondary level graduates in Ethiopia, Malawi, Nigeria, and Tanzania respectively.

Table 4: Relationship between education and outcome variables

Country	Highest level of schooling completed	Outcome variables					
		Improved seed	Credit access	Fertilizer use	Consumption expenditure (per capita)	Log Cons. expenditure (per capita)	Poverty
Ethiopia (n=6794)	No school	0.13	0.11	0.57	5332	8.36	0.45
	Primary	0.14	0.13	0.63	5630	8.42	0.40
	Secondary	0.24	0.14	0.59	6429	8.58	0.22
	Post-Sec	0.48	0.39	0.57	9804	8.96	0.14
	Total	**0.18**	**0.06**	**0.56**	**5758**	**8.43**	**0.41**
Malawi (n=5848)	No school	0.19	0.06	0.45	128324	11.55	0.40
	Primary	0.19	0.09	0.42	156543	11.74	0.29
	Secondary	0.27	0.09	0.45	171038	11.81	0.23
	Post-Sec	0.39	0.18	0.50	376710	12.40	0.16
	Total	**0.26**	**0.07**	**0.42**	**153545**	**11.66**	**0.35**
Nigeria (n=6276)	No school	0.14	0.01	0.40	79422	11.12	0.76
	Primary	0.15	0.02	0.43	88192	11.23	0.69
	Secondary	0.25	0.08	0.49	104613	11.38	0.27
	Post-Sec	0.33	0.12	0.59	140659	11.66	0.19
	Total	**0.14**	**0.03**	**0.41**	**92378**	**11.25**	**0.67**
Tanzania (n=4722)	No school	0.14	0.03	0.09	597155	13.14	0.56
	Primary	0.19	0.03	0.16	623922	13.13	0.46
	Secondary	0.28	0.11	0.27	801712	13.37	0.19
	Post-Sec	0.31	0.13	0.33	1107549	13.62	0.17
	Total	**0.17**	**0.04**	**0.18**	**667091**	**13.20**	**0.42**

Source: author's compilation.

3.3.3 Descriptive statistics and test of mean differences of explanatory variables used in regression models

Table 5 presents the descriptive statistics of the explanatory variables used in the regression models. We present the mean values of these explanatory variables by level of education. Furthermore, we present a test of difference in these mean values in Table 5. The test of differences in means for the explanatory variables between the "no schooling" as the reference group and the "Primary", "Secondary", and "Post-secondary" levels. If the mean difference is significant, we assign corresponding asterisk (***, **, * for 1%, 5%, and 10% level of significance respectively).

Results show that there exist a significant different in mean values of the dependent and independent variables between the no-schooling group and the other groups across the four countries. Overall, for the outcome variables, the results indicate significantly higher proportion of use of improved seed varieties among individuals who have completed secondary level and post-secondary level of education as compared to the 'no-school' individuals. Additionally, there is significant higher, though marginally, use of improved seeds varieties among primary graduates in Nigeria. Similar findings are recurrent with respect to the use of fertilizers and access to agricultural credit in all the countries except Malawi where significant difference begins to be noted only after completed post-graduate level. These findings on improved seeds varieties and fertilizer may be particularly so due to the nature of smallholder production in which improved seed varieties and fertilizers are seen as complementary, especially staple crops such as maize. Per capita consumption expenditure is significantly higher for every level of education completed in all four countries.

Table 6: Descriptive statistics and test of mean differences of variables used in regression models

	Ethiopia (n=6794)				Malawi (n=5848)				Nigeria (n=6276)				Tanzania (n=4722)			
	No school	Pri.	Sec.	Post-sec	No school	Pri.	Sec.	Post-sec	No school	Pri.	Sec.	Post-sec	No school	Pri.	Sec.	Post-sec
Improved seed	0.13	0.14	0.24**	0.48***	0.19	0.19	0.27***	0.39***	0.14	0.15*	0.25***	0.33***	0.14	0.19	0.28**	0.31***
Credit access	0.11	0.13	0.14**	0.39***	0.06	0.09***	0.09***	0.18***	0.01	0.02	0.08**	0.12***	0.03	0.03	0.11***	0.13***
Fertilizer use	0.57	0.63***	0.59**	0.67***	0.45	0.42	0.45	0.50**	0.40	0.43**	0.49***	0.59***	0.09	0.16***	0.27***	0.33***
Cons. exp	5332	5630***	6429***	9804***	128324	156543*	171038***	376710**	79422	88192**	104613**	140659**	597155	623922*	801712*	1107549**
Log cons. exp	8.36	8.42***	8.58**	8.96***	11.55	11.74***	11.81**	12.40***	11.12	11.23***	11.38***	11.66***	13.14	13.28***	13.37***	13.62***
Poverty	0.45	0.40***	0.22***	0.14**	0.40	0.29***	0.23***	0.16***	0.76	0.69***	0.27***	0.19***	0.56	0.46**	0.19***	0.17***
age	49.83	40.16***	37.20**	34.71***	45.71	38.59**	39.26***	39.11***	58.03	51.88***	44.2	51.27	53.96	41.5***	44.8***	45.59***
sex	0.82	0.80	0.79***	0.79***	0.88	0.88	0.85	0.87	0.82	0.83***	0.88	0.79	0.78	0.81***	0.83***	0.84***
hhsize	4.86	5.63	3.34***	3.93***	5.06	5.06	5.35***	4.68***	5.49	5.56	5.55	6.11	5.68	5.76	5.72	5.90
lnmrkt_dist	3.89	3.94	3.98	3.91	2.03	2.00	1.97	1.75**	4.11	4.05**	4.06*	4.14	3.96	3.98	3.65	3.37***
lndis_dist.	4.77	4.73	4.84	4.68	3.49	3.45	3.34	3.17	4.09	3.89***	3.96**	3.88	4.60	4.52	4.54	4.45
extension	0.27	0.30	0.27	0.10	0.31	0.31	0.33	0.22**	0.04	0.04	0.05	0.06	0.11	0.17*	0.14	0.13
farmsize	1.17	1.25	1.20	0.53	1.86	1.81	1.82	1.64	0.99	0.81	0.92	0.95	6.51	6.69	5.01	4.92
remittances	0.10	0.11	0.12	0.13	0.10	0.12	0.18*	0.13**	0.18	0.15	0.11	0.14	0.19	0.15	0.15	0.13
goats	2.55	1.88**	1.61***	0.83***	1.20	1.13	0.98	0.51	3.26	2.75**	1.90***	1.93***	4.33	4.70	2.24***	2.58***
cattle	3.13	3.29	3.03	1.69	0.31	0.31	0.25	0.42	2.83	23.83	0.39	0.42	3.06	2.63**	1.94*	1.36***
radio	0.24	0.43	0.51***	0.69***	0.50	0.64***	0.74***	0.75***	0.63	0.74**	0.74**	0.99***	0.77	0.75	0.90***	1.11***
tv	0.04	0.07*	0.15**	0.43***	0.06	0.12***	0.21***	0.64***	0.17	0.34***	0.52***	0.93***	0.03	0.01	0.14***	0.43***
fridge	0.02	0.02	0.05***	0.09***	0.02	0.03	0.06***	0.41***	0.05	0.09**	0.15***	0.41***	0.01	0.00	0.05	0.23
bike	0.02	0.03	0.06*	0.09	0.47	0.57***	0.60***	0.56***	0.30	0.36	0.30	0.29	0.54	0.69	0.70	0.72
mbike	0.01	0.02	0.04***	0.05***	0.01	0.01	0.01	0.02	0.32	0.44***	0.53	0.64***	0.02	0.02	0.08	0.11***
rooms	1.64	1.87	2.01***	2.23***	2.40	2.58*	2.71***	2.88***	3.91	3.97	3.81	4.75***	3.48	3.52	3.72	4.19***
impwall	0.50	0.56***	0.61***	0.62**	0.44	0.56***	0.63***	0.73**	0.30	0.48	0.52	0.71	0.23	0.30	0.55***	0.63***
improof	0.43	0.50***	0.56**	0.59***	0.28	0.42*	0.57***	0.75**	0.72	0.81	0.86	0.94	0.46	0.50	0.82***	0.87***
impfloor	0.03	0.06*	0.11	0.30	0.18	0.31***	0.44***	0.69***	0.52	0.63***	0.72*	0.86***	0.17	0.11	0.57***	0.69**
elect	0.57	0.60**	0.64***	0.78***	0.03	0.08	0.13***	0.45***	0.26	0.42***	0.48***	0.67***	0.05	0.02	0.17	0.43***
imptoil	0.53	0.69***	0.77	0.82	0.03	0.06	0.07	0.25	0.38	0.51**	0.48**	0.69***	0.03	0.01	0.17**	0.36***
lntemp	5.25	5.26	5.24	5.25	5.37	5.36	5.35	5.33	5.58	5.57	5.57	5.57	5.42	5.40	5.44	5.43
lnrain	6.87	6.94	6.99	6.96	6.94	6.96	6.97	6.95	7.06	7.19	7.27*	7.26	6.92	6.92	7.06	7.00
lnelevation	7.44	7.46	7.47	7.42	6.71	6.76	6.81	6.87	5.46	5.33	5.18	5.20	6.22	6.70	5.77	5.99
terr_plains	0.16	0.13	0.13	0.18	0.48	0.44	0.36	0.34	0.69	0.69	0.67	0.66	0.57	0.47	0.63	0.65
terr_plat	0.54	0.56	0.61*	0.66***	0.44	0.48	0.56	0.61**	0.29	0.30	0.31	0.34	0.33	0.41	0.29	0.28
terr_hills	0.21	0.25	0.21	0.12	0.08	0.09	0.08	0.04	0.02	0.01	0.02	0.00	0.08	0.10	0.07	0.07

The values presented in this table are mean differences between the corresponding level education completed and the base category (no schooling).
***, **, * represent 1%, 5%, and 10% significance level respectively.
Source: author's compilation.

Consequently, poverty measured as proportion of households whose consumption expenditure is below the national poverty line, is significantly lower for every level of education completed in all the four countries.

Regarding the explanatory variables, significant differences in mean values can are report for several demographic, socioeconomic, and biophysical variables. For examples, the mean age of the sampled household heads is significantly younger for all the levels of education completed as compared to 'no school' group in all the four countries. In Ethiopia for instance, the mean age is 40 years (primary), 37 years secondary) and 35 years (post-secondary) as compared to 49.8 years for 'no school' group. Among the economic variables, the number of goats owned by the household is significantly lower with increasing level of education in Ethiopia, Nigeria, and Tanzania. In Nigeria for instance, the number of goats among the primary graduates is 2.8 (primary), 1.9 (secondary and post-secondary) as compared to 3.3 for the base category.

With regards to housing condition, results generally shows that households with higher levels of education (secondary and above) have better living/housing conditions. They residences have improved walls, improved floors, improved roofs, and have netter access to electricity as compared to the base group. For instance, in Nigeria, the proportion of households with improved floor was 63%, 72%, 86% among primary, secondary and post-secondary level of educated respectively in comparison to about 52% among the 'no schooling' group. Similarly, in Ethiopia, access to electricity was also higher among primary graduates (60%), secondary level category (64%) and post-secondary level (78%) as compared to 57% of the 'no schooling' group. Access to improved toilet is significantly higher in Tanzania (51% for primary group, 58% for secondary group, and as high as 69% for post-secondary level. This is in comparison to just about 38% for 'no schooling'.

There were largely no significant differences between the base group with those with at least primary level of education with regards to biophysical variables (terrain, temperature, rainfall, and elevation) and also with some other socio-economic variables such as farm size, access to extension services and remittance.

4. Impact of education on outcome variables: multinomial treatment model results

The first stage (choice equations) of the multinomial treatment effect model applied in this study is the estimation of the determinants of the different levels of education (primary, secondary, post-secondary) completed. The base/comparison category is the immediate lower level of education (i.e. the comparison category for primary level or education is the no-schooling group, while the base category for secondary level is the primary school category and the comparison group for post-secondary education is the secondary level of education. In this way, we are able to estimate the incremental effect of education. For prudence, we do not we present and discuss the results of this stage. However, we avail numerous tables (Tables B1-B4) at appendix – in which we show that these results are generally consistent with expectations. We have also estimated the effect of education on the outcome variable with the base category set as no school for robust checks and the results are also placed in appendix C1. We must note here that, overall, we find the marginal effects of the exclusion restrictions to point in a reasonable direction and explain the endogenous nature of the level of education on the outcome variables (that is, parents' level of education are statistically significant confirming the validity of our exclusion restrictions) (Tables B1-B4). This is in line with prior evidence that parents' level of education plays a role in enhancing their willingness to invest in their children's human capital development though education and subsequently on efficacy of return to education (Altonji and Dunn, 1996; Maluccio, 1998; Holmlund et al, 2016; Havari and Savegnago, 2016).

Thus, we only discuss here the results (marginal effects) of the second stage (outcome equation) in this section as presented in Table 6. We must further note that due to complexity of describing each of the results for the several outcome variables and the multiple equations estimated for each country, we only

focus on the most relevant coefficients (i.e. results of the 'treatment' variable). We prefer to report marginal effects instead of the coefficients for simplicity and for proper inference. Full estimation results for each of the four countries are reported in Tables A1 – A4 in the Appendix. Summary of the results of the second stage multinomial treatment effect models on the effect of level of education on use of improved seed varieties, access to credit services, use of fertilizers, consumption expenditure, and on poverty are presented in Table 6.

In the estimation of the impact of education on the use of improved seeds, all the sample selection bias correction terms (λ) are either negative or positive but all statistically significant coefficients. This imply that without controlling for selection bias the estimated impact of education would have been downwardly biased or upwardly biased respectively. The results show that after controlling for biophysical, socio-economic, demographic, and regional determinants, education (secondary and above), as compared to those with no schooling at all, significantly increases the use of improved seed varieties among small holder farmers in all the four countries and from primary level in Ethiopia and Nigeria. Fox example, farm households in Ethiopia and Nigeria with household heads who have at least completed primary level of education increased the use of improved seed varieties by 22% and 4% respectively. Furthermore, the use of improved seed varieties increased by 18%, 23%, 4%, and 17% in Ethiopia, Malawi, Nigeria, and Tanzania for secondary school graduates (Table 6). The incremental effect of education can be seen further in all the four countries; the use of improved seed varieties increases by 10% in Ethiopia, 15% in Malawi, 16% in Nigeria and 22% in Tanzania for tertiary level graduates. This finding on the positive effect of education on use of improved seed varieties is in line with earlier studies in Kenya which found increasing years of formal education would improve the adoption of maize technologies (fertilizer and hybrid seed) in Kenya and Zambia (Jayne et al., 2006; Olwande et al., 2009).

In the estimation of the impact of education on access to credit, several sample selection bias correction terms (λ) have either negatively or positively statistically significant coefficients. This imply that without controlling for selection bias on these particular equations will either downwardly bias or upwardly bias the estimated impact of education on access to credit services/loans respectively. The results show that after controlling for biophysical, socio-economic, demographic, and regional determinants, completing primary, secondary, and post-secondary level education significantly increases access to credit by 443%, 322%, and 302% respectively among small holder farmers in Malawi. Similarly, secondary graduates (compared to primary level graduates) increased access to credit services by 17% in Ethiopia and 39% in Nigeria. But perhaps more importantly, tertiary level of education (compared to secondary level) raises the access to credit by 49% in Ethiopia, 41% in Nigeria and a whopping 126% in Tanzania. This corroborates earlier findings that higher levels of illiteracy may limit access to financial resources and the use of technologies and innovations among farmers in developing countries (World Bank, 2011).

Similarly, in the estimation of the impact of education on use of fertilizers (Table 6), several sample selection bias correction terms (λ) have either negatively or positively statistically significant coefficients. This imply that without controlling for selection bias on these particular equations will either downwardly bias or upwardly bias the estimated impact of education on the use of this productive input respectively. The results show that after controlling for biophysical, socio-economic, demographic, and regional determinants, completing primary level education (compared to illiterate group) significantly increases use of fertilizer by 27% in Malawi, 17% in Nigeria and 28% in Tanzania. Further, completing secondary level of education would improve the use of fertilizers by 21% in Ethiopia, 7% in Nigeria, and 11% in Tanzania. Finally, completing tertiary level of education (compared to the secondary level) will increase use of fertilizer by about 68% in Ethiopia, 56% in Malawi, 8% in Nigeria and 2.4% in Tanzania. This finding on fertilizer use is similar to several earlier studies that found that farmers' level of education stimulates adoption and intensity of use fertilizers (Abdoulaye and Sanders, 2003; Freeman & Omiti, 2003; Chirwa, 2005; Diiro and Sam 2015; Jayne et al., 2006; Olwande et al., 2009). Our finding shows the importance and the incremental effect of education from primary to post-secondary.

Table 6: Incremental effect of education on outcome variables

Outcome Variable	Country	Primary[4]	Secondary[5]	Post-Sec[6]	λ (Primary)	λ (Secondary)	λ (Post-sec)
Use of improved seed varieties	Ethiopia (n=6794)	0.227**	0.180*	0.100***	-0.025***	0.055***	-0.015**
	Malawi (n=5848)	0.138	0.234**	0.152*	0.054	-0.003**	-0.008***
	Nigeria (n=6276)	0.042**	0.042**	0.159***	0.026***	0.102***	0.082**
	Tanzania (n=4722)	0.07	0.165**	0.215**	-0.032*	-0.203*	-0.091***
Access to credit	Ethiopia (n=6794)	0.083	0.167*	0.486***	0.222***	-0.011**	0.031**
	Malawi (n=5848)	4.429***	3.220**	3.018***	-1.670***	0.024**	-2.758***
	Nigeria (n=6276)	-0.222	0.386**	0.411***	0.114	0.103***	-0.049***
	Tanzania (n=4722)	0.479	-0.127	1.261***	1.340***	0.161	0.348***
Use of fertilizers	Ethiopia (n=6794)	0.032	0.210*	0.683***	0.133***	-0.005	-0.028
	Malawi (n=5848)	0.270***	-0.342	0.557***	-0.328***	-0.02***	0.015***
	Nigeria (n=6276)	0.165**	0.073***	0.083*	-0.018**	0.012**	0.010***
	Tanzania (n=4722)	0.277**	0.011**	0.024**	0.162	-0.024	0.100*
Per capita consumption expenditure	Ethiopia (n=6794)	434.7**	330.1***	1709.2***	241.6***	76.4***	23.6
	Malawi (n=5848)	6629.1	2477.8**	75159.8***	7091.5***	190.5	793.5***
	Nigeria (n=6276)	2714.1*	11508.8***	24315.5***	2593.1***	736.7***	520.1***
	Tanzania (n=4722)	2.92e+04*	17611.9	77675.1**	88082.1**	1.1e+04*	298.7
Log per capita consumption expenditure	Ethiopia (n=6794)	0.041	0.14***	0.142***	-0.05***	0.029	0.065**
	Malawi (n=5848)	0.032***	0.220**	0.196**	0.124***	0.017***	0.047***
	Nigeria (n=6276)	0.056	0.091***	0.148***	-0.033*	0.012***	-0.014***
	Tanzania (n=4722)	0.227***	0.214*	0.049**	0.265***	0.048*	-0.025**
Poverty	Ethiopia (n=6794)	-0.266*	-0.134***	-0.354***	-0.067***	-0.01	-0.049***
	Malawi (n=5848)	-0.146	-0.059**	-0.328**	-0.278**	-0.014**	-0.156***
	Nigeria (n=6276)	-0.246***	-0.616**	-0.416***	-0.388**	-0.27***	0.038
	Tanzania (n=4722)	-0.2	-0.339***	-0.653***	-0.293**	-0.24***	-0.097***

Notes: The models were estimated using Maximum Simulated Likelihood with 1000 draws.
****, **,*represent 1%, 5%, and 10% significance level respectively.
Source: author's compilation.

[4] With no-schooling as base category
[5] With primary level of education as a base category
[6] With secondary level of education as bases category

In the estimation of the impact of education on log per capita consumption expenditure (Table 6), all but one sample selection bias correction terms (λ) are statistically significant with accompanying negatively or positively coefficients. This also imply that without controlling for selection bias on these particular equations will either downwardly bias or upwardly bias the estimated impact of education on the use of this productive input respectively. The results show that after controlling for biophysical, socio-economic, demographic, and regional determinants, completing primary level education (compared to illiterate group) significantly increases log per capita consumption expenditure by just about 3% in Malawi and 23% in Tanzania. Further, completing secondary level of education (compared to primary level) would increase log per capita consumption expenditure by 14% in Ethiopia, 22% Malawi, 9% in Nigeria and 21% in Tanzania. Moreover, completing tertiary level of education (compared to secondary) will further increase log per capita consumption expenditure by about 14% in Ethiopia, 20% in Malawi, 15% in Nigeria, and 45% in Tanzania.

Finally, related to consumption expenditure is the estimation is the estimation of the impact of education on poverty (households whose per capita consumption expenditure is less than the nationally constructed poverty line), most of the sample selection bias correction terms (λ) are statistically significant with accompanying negatively or positively coefficients (Table 6). This also imply that without controlling for selection bias on these particular equations will either downwardly bias or upwardly bias the estimated impact of education on the use of this productive input respectively. The results show that after controlling for biophysical, socio-economic, demographic, and regional determinants, completing primary level education (compared to illiterate group) significantly reduce poverty by about 27% and 25% in Ethiopia and Nigeria respectively.

Furthermore, completing secondary level of education (compared to primary level) reduces household poverty by about 13% in Ethiopia, 6% in Malawi, 61% in Nigeria, and 33% in Tanzania. Completing tertiary level of education has even greater importance in reducing household poverty – reduces poverty by about 35% in Ethiopia, 33% in Malawi, 41% in Nigeria, and 65% in Tanzania. Unlike previous studies (Berg, 2008; Janjua and Kamal, 2011; De Silva and Sumarto, 2015) that used proxies for poverty (such as income and per capita growth) and education (such as education capital), our study directly estimates the impact of education level of the principle decision maker in the household directly on standard poverty measure. Albeit, we find consistent results to these earlier studies that the linkages between education and poverty is significant and must not be ignored in development policy. Improving access to education is significant in alleviating poverty. Indeed, these findings confirms our hypothesis that higher education (secondary and post-secondary levels) is by far the most important factor in poverty reduction than mere introductory literacy and primary learning. On poverty, our findings corroborates the World Development Report's (WDR, 2018) finding that a properly structured and well delivered education promotes employment, earnings, health, and poverty reduction.

5. Conclusions

It is widely recognized by development scholars and practitioners that human capital and skill development are significant determinants that could positively affect farmers' performance and their disposition to adopt innovations. Education (general, as well as specific agricultural education and training), is argued as vital to overcoming development challenges in rural areas. This study assess the impact of higher education on short-term economic outcomes (use of agricultural inputs–improved seeds, fertilizers, access to credit facilities (loans)), and on intermediate to longer-term economic outcomes (consumption expenditure and poverty) among smallholder farmers in four countries in SSA Africa (Ethiopia, Malawi, Nigeria and Tanzania). We apply a multinomial endogenous treatment model with education as our 'treatment' variable with four possible levels (no-schooling, primary, secondary, post-secondary). The empirical model jointly

estimates treatment and selection effects and by this corrects for selection into one or the other education level.

Using nationally representative LSMS panel data allows us to comprehensively assess the impact of education on the outcome variables. Overall results suggest that higher education (secondary and post-secondary level) significantly increases the use of improved seed varieties and fertilizers, access to credit services, and per capita consumption expenditure and consequently reduces household poverty.

Our results on positive effect of education on use of improved seed varieties seem to be in line with earlier studies which found increasing years of formal education would improve the adoption of maize technologies. For example, our findings show that the use of improved seed varieties increased by 18%, 23%, 4%, and 17%in Ethiopia, Malawi, Nigeria, and Tanzania for secondary level of education. The incremental effect of education can be seen further in all the four countries; the use of improved seed varieties increases by 9% in Ethiopia, 22% in Malawi, 10% in Nigeria and 23% in Tanzania for tertiary level of education. Furthermore, the findings on positive effect of education on fertilizer use is similar to earlier studies that found that farmers' level of education stimulates adoption and intensity of use fertilizers. For example, our results show that completing tertiary level of education (compared to the 'no-school' group) will increase use of fertilizer by about by 10% in Ethiopia, 15% in Malawi, 16% in Nigeria and 22% in Tanzania. Our results also provide evidence that corroborates the commonly held perception that higher levels of illiteracy may limit access to financial resources and the use of technologies and innovations among farmers in developing countries. For instance, having completed post-secondary education (as compared to secondary level) increase access to credit services by 49% in Ethiopia, 41% in Nigeria and a whopping 126% in Tanzania.

Our findings have shown that completing tertiary education (as compared with secondary level of education) increases household per capita consumption expenditure by 14% in Ethiopia, 20% in Malawi, 15% in Nigeria, and 45% in Tanzania. Consequently, completing tertiary education significantly reduce household poverty by about 35% in Ethiopia, 33% in Malawi, 41% in Nigeria, and 65% in Tanzania. Unlike previous studies that used proxies for poverty (such as income and per capita growth) and education (such as education capital), our study directly estimates the impact of education level of the principle decision maker in the household directly on standard poverty measure. Albeit, we find consistent results to these earlier studies that the linkages between education and poverty is significant and must not be ignored in development policy. This also corroborates the World Development Report's finding that a properly structured and well delivered education promotes employment, earnings, health, and poverty reduction.

Overall, these findings augment the conclusion that schooling have positive impacts for the farmers and their households' well-being. The findings are of policy relevance to most SSA countries currently grappling with rising urbanization, high youth unemployment, and acute skills shortage. Education investment is crucial for income generation and for poverty reduction. In the absence of formal secondary education and rather aging farmers, special focus should be given to promoting vocation training among smallholder farmers. The vocational skills learned wound provide insights needed to engage in farming and adopt environmentally sustainable production methods and to augment agricultural incomes.

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Appendix A: Impact of education on outcome variables by country

Table A1: Impact of education on outcome variables in Ethiopia

	Seed	Credit	Fertilizer	Cons. exp.	Log cons. exp.	Poverty
Primary	0.227**	0.089	0.032	434.718**	0.041	-0.266***
Secondary	0.089**	0.250*	0.012	764.844***	0.181***	-0.400***
Post-sec	0.09***	0.736***	0.695***	2474.045***	0.323***	-0.754***
age	-0.01	0.022	0.051***	-72.413***	-0.008***	0.035***
agesq	0	-0.000*	-0.000***	0.658***	0.000***	-0.000***
sex	-0.032	-0.252**	-0.333***	283.566*	0.013	0.023
hhsize	0.033	0.079***	0.111***	-542.625***	-0.092***	0.301***
lnmrktdist	-0.109*	-0.110*	0.032	-32.541	-0.041***	0.136***
lndisdist	-0.026	-0.343***	-0.407***	180.201*	0.038***	-0.112***
extprogram	1.741***	0.009	3.347***	-9.486	0.031*	-0.084
farmsize	0.007	-0.043	0.175***	7.099	0.002*	-0.107***
goats	-0.006	-0.027**	-0.046***	-4.037	0	0.001
cattle	0.029***	-0.030**	0.101***	82.263***	0.016***	-0.049***
radio	0.159**	-0.02	-0.016	756.958***	0.150***	-0.487***
tv	0.468**	0.234	-0.751***	1742.834***	0.196***	-0.831***
fridge	-0.454	-0.587*	-0.364*	962.258***	0.077*	-0.221
bike	0.606**	0.267	0.641***	-589.585	-0.047	0.128
mbike	-0.662**	-0.17	0.32	-1870.029***	-0.264***	1.077***
rooms	-0.046	-0.132***	0.071*	228.580***	0.044***	-0.165***
impwall	-0.267***	-0.317***	0.347***	170.236	-0.014	0.120*
improof	0.695***	0.034	0.255***	-243.236*	-0.050***	0.078
impfloor	0.1	-0.235	-0.373**	942.507***	0.138***	-0.662***
elect	-1.951***	-1.707***	-0.246***	35.684	0.109***	-0.170**
imph20	0.442***	0.741***	-0.256***	256.096	-0.007	-0.088
imptoil	0.112	0.167*	0.307***	406.700***	0.062***	-0.151**
lntemp	3.237***	1.221*	5.220***	-2179.003***	-0.288***	1.355***
lnrain	0.360**	0.592***	0.726***	-1410.324***	-0.226***	0.783***
lnelevation	1.580***	0.452	5.288***	33.363	0.043	0.098
terr_plains	0.31	-0.254	-0.156	723.322**	0.178***	-0.484***
terr_plat	0.422**	0.286*	-0.023	788.121***	0.164***	-0.525***
terr_hills	-0.038	0.171	0.456***	530.865*	0.046	-0.143
aez	0.082***	0.042	-0.044**	-39.387	-0.009**	0.021
region	0.095***	-0.165***	-0.008	103.760***	0.016***	-0.059***
_cons	-60.247***	-26.521***	-58.409***	39870.073***	14.190***	-21.299***
λ (Primary)	-0.025***	0.222***	0.133***	241.596***	-0.05***	-0.067***
λ (Secondary)	0.055***	-0.011**	-0.005	76.442***	0.029	-0.01
λ (Post-sec)	-0.015**	-0.031**	-0.028	23.624	0.065**	-0.049***
lnsigma				8.546***	-0.574***	
N	6794	6794	6794	6794	6794	6794
chi2	3004.771	2734.895	3559.025	3174.978	3801.357	2589.244
p	0	0	0	0	0	0

Notes: The models were estimated using Maximum Simulated Likelihood with 1000 draws.
***, **, * represent 1%, 5%, and 10% significance level respectively.
Source: author's compilation.

Table A2: Impact of education on outcome variables in Malawi

	Seed	Credit	Fertilizer	Cons. exp.	Log cons. exp.	Poverty
Primary	0.138	4.429***	0.270***	6629.099	0.032***	-0.146
Secondary	0.172	1.428***	-0.108	9106.868**	0.054**	-0.205**
Post-sec	-0.024	1.397***	0.459***	84266.707***	0.250***	-0.533**
age	0.040***	0.094*	0.058***	912.027	-0.004	0.027**
agesq	-0.000*	-0.001**	-0.000***	-11.212*	0	-0.000*
sex	0.134	0.07	0.08	-3609.71	-0.040**	0.015
hhsize	0.018	0.027	0.006	-2.44e+04***	-0.136***	0.471***
lnmrktdist	0	0.208	-0.173***	-3937.03	0.001	0.015
lndisdist	-0.063	2.207***	0.095**	7635.465***	0.024***	-0.062
extinfo	0.539***	-0.077	0.361***	481.82	0.043***	-0.205***
farmsize	0.062**	0.011	0.112***	5319.737***	0.035***	-0.145***
goats	-0.006	-0.033	0.036***	839.332	0.009***	-0.050***
cattle	-0.038	-0.073	-0.024	149.268	0.001	-0.049
radio	0.144***	0.034	0.076*	13053.178***	0.112***	-0.627***
tv	-0.239	-0.304	-0.316**	42653.810***	0.181***	-1.908***
fridge	-0.058	0.507	-0.219	1.06e+05***	0.156***	0.386
bike	0.132**	0.145	0.266***	1118.324	0.050***	-0.291***
mbike	0.529	0.042	0.016	1.25e+05***	0.142**	-1.467*
rooms	0.210***	0.263**	0.151***	14126.822***	0.074***	-0.310***
impwall	0.149*	0.056	0.174**	10918.536**	0.078***	-0.144*
improof	-0.115	0.43	-0.163*	13520.554**	0.137***	-0.535***
impfloor	-0.537***	0.035	-0.715***	17927.180***	0.119***	-0.342***
elect	-0.770**	0.102	-0.634***	66489.937***	0.276***	-1.095***
imph20	0.434***	-0.435	0.107	-2738.7	0.007	0.056
imptoil	-0.937***	1.048*	-0.681***	1.26e+05***	0.235***	-0.332
lntemp	11.297***	-18.837***	9.866***	-1.39e+05***	-0.682***	2.362***
lnrain	0.387	-0.415	0.507**	#########	-0.134***	0.549**
lnelevation	1.602***	-1.958***	2.300***	-1633.37	0.098***	-0.245*
terr_plains	-0.183	0.298	0.079	-1072.94	-0.007	0.008
terr_plat	-0.283**	-0.708	-0.209*	2404.725	0	-0.09
aez	0.127***	0.055	0.050***	-4564.829***	-0.021***	0.056***
aez2	0.545***	0.019	0.109	-5092.38	0.035*	-0.074
aez4	-0.636***	-2.100***	-0.038	23482.124***	0.092***	-0.145
region2	0.470***	0.984***	0.429***	-7536.382**	-0.023**	0.01
_cons	-119.063***	79.441**	-91.346***	2.51e+06***	22.421***	-33.969***
λ (Primary)	0.054	-3.670***	-0.328***	7091.535***	0.124***	-0.278**
λ (Secondary)	-0.003**	0.024**	-0.02***	-190.543	0.017***	-0.014**
λ (Post-sec)	-0.008***	-2.758***	0.015***	1793.49***	0.047***	-0.156***
lnsigma				-0.747***		11.808***
N	5848	5848	5848	5848	5848	5848
chi2	1638.687	1263.911	1995.758	5796.001	7294.231	2068.862
p	0	0	0	0	0	0

Notes: The models were estimated using Maximum Simulated Likelihood with 1000 draws.
***, **, * represent 1%, 5%, and 10% significance level respectively.
Source: author's compilation.

Table A3: Impact of education on outcome variables in Nigeria

	Seed	Credit	Fertilizer	Cons. exp.	Log cons. exp.	Poverty
Primary	0.042**	-0.222	0.165**	2714.061*	0.056	-0.246***
Secondary	0.044**	0.564**	0.092***	14222.879***	0.147***	-0.862***
Post-sec	0.103***	0.678***	0.175*	38538.366***	0.295***	-1.078***
age	-0.012***	0.092*	-0.001	-147.402***	-0.001	0.002
agesq	0.000***	-0.001**	0	0.120**	0	0
sex	-0.491***	-0.442	-0.410***	1020.045	0.015	-0.055
hhsize	-0.067***	-0.021	0.048***	-8591.236***	-0.089***	0.465***
lnmrktdist	-0.04	0.019	-0.388***	-4411.620***	-0.039***	0.180***
lndisdist	-0.123***	-0.269**	0.073*	-5093.990***	-0.039***	0.172***
extn	0.243	0.51	0.389***	5050.297	0.056**	-0.411**
farmsize	-0.048	0.105*	0.017	2845.524***	0.032***	-0.159***
goats	0.004	0.008	0.043***	-107.673	-0.001	-0.001
cattle	-0.008	-0.002	-0.014***	-0.288	0	0.005
radio	-0.048	0.224*	0.037	5047.976***	0.053***	-0.167***
tv	-0.259***	-0.124	-0.114**	7153.989***	0.078***	-0.450***
fridge	0.192*	0.109	-0.202**	19645.959***	0.148***	-0.884***
bike	0.229***	0.274**	0.268***	-3276.134***	-0.020**	0.137**
mbike	-0.118*	-0.166	0.228***	4051.620***	0.076***	-0.290***
rooms	0.052***	-0.002	0.041***	1090.685***	0.010***	-0.033**
impwall	0.352***	0.087	-0.219***	6134.470***	0.059***	-0.176*
improof	-0.003	-0.154	0.303***	3495.642*	0.070***	-0.312***
impfloor	-0.013	0.161	0.149*	9409.124***	0.121***	-0.516***
elect	-0.065	0.3	0.051	11575.963***	0.134***	-0.489***
imph20	-0.139*	0.073	0.053	-2149.64	-0.029**	0.06
imptoil	0.024	0.166	-0.039	7752.230***	0.109***	-0.388***
lntemp	10.442***	1.937	11.652***	-1.25e+05***	-1.376***	5.005***
lnrain	1.146***	-0.16	1.389***	-2.42e+04***	-0.360***	1.528***
lnelevation	0.358***	0.234	0.919***	-6782.126***	-0.088***	0.284***
terr_plains	-0.351	-0.038	0.201***	-6594.286***	-0.074***	0.205**
terr_hills	-0.366	-0.803	-0.479*	-318.851	0.024	0.532*
aez	0.114***	0.023	0.251***	-687.417	0.001	-0.029
aez2	-0.720***	0.016**	-1.547***	8608.808***	0.143***	-0.867***
aez3	-1.645***	0.033***	-2.122***	3667.182	0.092**	-0.805***
region	0.131***	0.375***	-0.090***	1233.979**	0.007	-0.038
_cons	-103.521***	-24.005	-156.822***	1.26e+06***	21.892***	-31.447*
λ (Primary)	0.026***	0.114	-0.018**	2593.082***	-0.033*	-0.388**
λ (Secondary)	0.102***	0.103***	0.012**	736.705***	-0.012***	-0.27***
λ (Post-sec)	0.082**	-0.049***	0.01***	520.074***	-0.014***	0.038
lnsigma				-0.810***		10.854***
N	6276	6276	6276	6276	6276	6276
chi2	2626.669	2891.168	3483.093	5670.042	6373.437	2808.919
p	0	0	0	0	0	0

Notes: The models were estimated using Maximum Simulated Likelihood with 1000 draws.
***, **, * represent 1%, 5%, and 10% significance level respectively.
Source: author's compilation.

Table A4: Impact of education on outcome variables in Tanzania

	Seed	Credit	Fertilizer	Cons. exp.	Log cons. exp.	Poverty
Primary	0.07	0.479	0.277**	2.92e+04*	0.227***	-0.200
Secondary	0.235**	-0.348	0.266**	1588.142	0.441*	-0.539***
Post-sec	0.23**	1.913***	0.740**	79363.162**	0.490**	-0.652***
age	0.058***	-0.045	0.049**	-1.08e+04***	-0.012***	-0.025*
agesq	-0.001***	0	-0.000**	81.624***	0.000***	0.000*
sex	0.403***	-0.027	0.223*	#######	-0.01	-0.062
hhsize	0.048***	0.123***	-0.108***	-4.36e+04***	-0.067***	0.315***
lnmrktdist	-0.136***	0.301*	0.121**	447.131	0.027***	-0.066
lndisdist	0.142**	-0.656***	0.018	23378.958***	0.045***	0.01
extinfo	-0.661***	-0.640**	-0.906***	4269.444	0.002	0.313***
farmsize	0	0.008	0.018***	3472.951***	0.005***	-0.025***
goats	0.001	-0.029	-0.037***	1869.058***	0.002***	-0.026***
cattle	0.004	-0.065**	-0.056***	4626.250***	0.007***	-0.044***
radio	-0.001	0	0.312***	612.506	0.002	-0.570***
tv	0.215	-0.413	0.216	1.59e+05***	0.144***	-0.814***
fridge	0.142	2.400***	0.326	2.64e+05***	0.192***	-0.15
bike	0.109**	-0.132	0.124*	30845.870***	0.085***	-0.153***
mbike	-0.071	0.595	-0.316	1.74e+05***	0.097**	-0.134
rooms	-0.004	0.172***	0.106***	-4952.65	0.002	0.01
impwall	-0.074	0.027	0.761***	14652.57	0.017	0.099
improof	0.463***	0.068	0.079	85709.614***	0.169***	-0.479***
impfloor	0.277**	0.843**	0.486***	1.30e+05***	0.159***	-0.643***
elect	-0.167	0.079	-0.189	1.52e+05***	0.173***	-0.622***
imph20	0.102	0.618**	0.265*	-4.67e+04**	-0.124***	-0.024
imptoil	-0.447**	-0.336	-0.540**	3.56e+05***	0.255***	-0.564**
lntemp	-1.818***	1.07	-7.089***	########	-0.208	1.617***
lnrain	-0.327*	-0.335	0.561***	-6308.65	0.051	-0.529***
lnelevation	0.157**	0.771***	0.145*	-3.62e+04***	-0.037***	0.146***
terr_plains	2.153***	1.86	1.820***	63176.31	0.08	-0.771***
terr_plat	2.130***	1.613	2.043***	53489.43	0.06	-0.501*
terr_hills	1.719***	0.92	1.367***	48723.97	0.101	-0.530*
aez	0.003	-0.003	-0.045***	3977.481**	0.004	-0.012
region	-0.009*	0.022	0.002	-5301.255***	-0.007***	0.026***
_cons	5.337	-11.28	43.116***	7.84E+05	13.382***	-2.622
λ (Primary)	-0.032*	1.340***	0.162	88082.055**	0.265***	-0.293**
λ (Secondary)	-0.203*	0.161	-0.024	1.08e+04*	0.048*	-0.24***
λ (Post-sec)	-0.091***	0.348***	0.100***	298.687	0.025**	-0.097***
lnsigma				-0.793***		13.006***
N	4722	4722	4722	4722	4722	4722
chi2	1827.458	1648.591	2205.352	3827.966	4035.607	2220.238
p	0	0	0	0	0	0

Notes: The models were estimated using Maximum Simulated Likelihood with 1000 draws.
***, **, * represent 1%, 5%, and 10% significance level respectively.
Source: author's compilation.

Appendix B: First stage (choice) regressions by country

Table B1: First stage regression: Determinants of level of education in Ethiopia

	Primary Level	Secondary Level	Post-Sec Level
dadedu	0.010***	0.012***	-0.014***
mumedu	0.006***	0.004	0.006**
age	-0.017	-0.092***	0.003
agesq	-0.000**	0	-0.001**
sex	-1.210***	-1.472***	-1.468***
hhsize	0.095***	0.070***	-0.288***
lnmrktdist	0.098*	0.117*	0.225**
lndisdist	-0.039	0.021	-0.182*
extprogram	0.043	-0.174	-0.937***
farmsize	-0.001	0.001	-0.043
goats	-0.017**	-0.005	-0.004
cattle	0.004	0.013	0.022
radio	0.434***	0.615***	0.858***
tv	-0.204	0.669***	1.840***
fridge	-0.669**	-0.237	-0.423*
bike	0.07	-0.083	-0.503
mbike	0.009	-0.316	-0.872**
rooms	0.087**	0.110**	0.125***
impwall	0.287***	-0.500***	-0.553***
improof	-0.464***	-0.349***	-0.587***
impfloor	0.517***	0.826***	1.649***
elect	1.162***	0.449***	1.040***
imph20	-0.170*	0.099	0.740***
imptoil	0.607***	0.917***	0.949***
lntemp	0.865*	-0.438	-1.609*
lnrain	0.066	0.340**	0.723***
lnelevation	0.392	-0.002	-1.260***
terr_plains	0.367*	0.571**	0.263
terr_plat	0.337**	0.433**	-0.093
terr_hills	0.495***	0.462**	-0.185
aez	-0.019	-0.026	0.004
region	0.030**	0.017	0.012
_cons	-2.32	9.917	12.534

***, **, * represent 1%, 5%, and 10% significance level respectively.
Source: author's compilation.

Table B2: First stage regression: Determinants of level of education in Malawi

	Primary Level	Secondary Level	Post-Sec Level
dadedu	0.302***	0.519***	0.577***
mumedu	0.300**	0.134	0.224*
age	-0.001	-0.048**	-0.004
agesq	0	0	0
sex	-0.401***	-0.688***	-0.926***
hhsize	-0.032	0.046*	-0.098***
lnmrktdist	-0.186**	-0.156*	-0.399***
lndisdist	0.068	-0.036	0.034
extinfo	0.02	0.224*	0.019
farmsize	-0.026	-0.024	-0.092
goats	0.002	-0.026	-0.054*
cattle	-0.006	-0.018	0.015
radio	0.086	0.135*	-0.037
tv	-0.112	0.065	0.540***
fridge	-0.421	-0.124	0.546***
bike	0.1	0.098	-0.05
mbike	0.421	-0.248	0.368
rooms	0.112**	0.074	0.152**
impwall	0.237**	0.344***	0.433***
improof	0.243	0.602***	0.486**
impfloor	0.248	0.429***	0.654***
elect	0.269	0.293	0.978***
imph20	0.074	0.398**	0.554**
imptoil	0.315	-0.196	0.272
lntemp	-1.138	-2.222	-1.72
lnrain	0.737**	0.524	0.303
lnelevation	-0.258	-0.241	0.249
terr_plains	-0.057	-0.299	0.328
terr_plat	0.065	0.133	0.42
aez	0.019	0.004	-0.016
aez2	-0.243	-0.203	-0.123
aez4	-0.524**	-0.787***	-0.882**
region2	-0.309***	-0.269***	-0.253**
_cons	-4.46	7.451	8.147

***, **, * represent 1%, 5%, and 10% significance level respectively.
Source: author's compilation.

Table B3: First stage regression: Determinants of level of education in Nigeria

	Primary Level	Secondary Level	Post-Sec Level
dadedu	0.449***	1.323***	1.357***
mumedu	0. 1140*	1. 170**	0.654***
age	0.050***	-0.012	0.066**
agesq	-0.000***	-0.000*	-0.001**
sex	1.485***	-0.387**	-0.07
hhsize	-0.01	0.044**	0.013
lnmrktdist	-0.074	-0.130*	0.274***
lndisdist	0.063	0.113*	0.214***
extn	0.113	0.433**	0.405
farmsize	0.03	0.055	0.035
goats	-0.007	-0.014	-0.022
cattle	0	-0.077***	-0.070**
radio	-0.140**	-0.027	0.200**
tv	-0.273***	0.081	0.282***
fridge	0.107	0.242*	0.725***
bike	0.032	-0.170**	-0.293***
mbike	-0.198***	0.038	0.058
rooms	0.030*	-0.024	0.019
impwall	-0.680***	-0.054	0.189
improof	-0.157	0.133	0.314
impfloor	0.125	0.148	0.524***
elect	-0.386***	0.088	0.336**
imph20	-0.656***	-0.258***	-0.036
imptoil	-0.322***	-0.112	0.490***
lntemp	2.174	-1.15	0.384
lnrain	-1.493***	0.569**	-0.812**
lnelevation	-0.096	-0.115	-0.132
terr_plains	0.049	0.016	0.053
terr_plat	0.064	0.545	-2.606**
aez	-0.034	0.067	0.162***
aez2	0.632***	0.197	0.818***
aez3	0.626**	-0.056	0.878**
region	-0.214***	-0.075**	-0.199***
_cons	6.629	-17.695	-53.837*

***, **, * represent 1%, 5%, and 10% significance level respectively.
Source: author's compilation.

Table B4: Table: First stage regression: Determinants of level of education in Tanzania

	Primary Level	Secondary Level	Post-Sec Level
dadedu	0.007*	0.089*	-0.058
mumedu	0.133***	-0.01	0.180**
age	0.127***	0.027	0.025
agesq	-0.002***	-0.001***	-0.001**
sex	0.385***	0.760***	0.758***
hhsize	-0.021	0.024	0.062*
lnmrktdist	-0.052	-0.130**	-0.207**
lndisdist	-0.184***	-0.065	-0.262***
extinfo	-0.372***	-0.702***	-0.835***
farmsize	0.003	-0.001	-0.001
goats	0.009**	-0.001	0.009
cattle	-0.016**	-0.011	-0.065***
radio	-0.004	-0.006	-0.001
tv	-0.757*	0.179	0.796***
fridge	0.417	0.049	0.967***
bike	0.262***	0.146*	0.091
mbike	-0.002	0.733***	0.446
rooms	0.063**	0.02	0.089**
impwall	0.210*	0.525***	0.360*
improof	0.278***	0.983***	0.740***
impfloor	-0.371***	1.208***	1.234***
elect	-0.679**	0.099	0.932***
imph20	-0.259**	0.184	-0.105
imptoil	-1.852***	0.553**	1.257***
lntemp	2.025***	-0.69	2.08
lnrain	0.707***	1.336***	1.009***
lnelevation	0.425***	-0.021	0.352***
terr_plains	0.489	0.917*	1.037
terr_plat	0.620*	0.885*	0.726
terr_hills	0.614*	0.378	0.191
aez	-0.013	-0.014	0.006
region	-0.031***	-0.002	-0.006
_cons	-15.327**	-3.433	-24.425*

***, **, * represent 1%, 5%, and 10% significance level respectively.
Source: author's compilation.

Table C1: Impact of education on outcome variables

Outcome Variable	Country	Primary	Secondary	Post-Sec	λ (Primary)	λ (Secondary)	λ (Post-sec)
Use of improved seed varieties	Ethiopia (n=6794)	0.227**	0.089**	0.09***	-0.025***	0.055***	-0.015**
	Malawi (n=5848)	0.138	0.172**	0.224*	0.054	-0.003**	-0.008***
	Nigeria (n=6276)	0.042**	0.044**	0.103***	0.026***	0.102***	0.082**
	Tanzania (n=4722)	0.07	0.235**	0.230**	-0.032*	-0.203*	-0.091***
Access to credit	Ethiopia (n=6794)	0.083	0.250*	0.736***	0.222***	-0.011**	0.031**
	Malawi (n=5848)	4.429***	1.428***	1.397***	-3.670***	0.024**	-2.758***
	Nigeria (n=6276)	-0.222	0.564**	0.678***	0.114	0.103***	-0.049***
	Tanzania (n=4722)	0.479	-0.348	1.913***	1.340***	0.161	0.348***
Use of fertilizers	Ethiopia (n=6794)	0.032	0.012***	0.695***	0.133***	-0.005	-0.028
	Malawi (n=5848)	0.270***	-0.108	0.459***	-0.328***	-0.02***	0.015***
	Nigeria (n=6276)	0.165**	0.092***	0.175*	-0.018**	0.012**	0.010***
	Tanzania (n=4722)	0.277**	0.266**	0.740**	0.162	-0.024	0.100*
Per capita consumption expenditure	Ethiopia (n=6794)	434.7**	764.8***	2474.0***	241.6***	76.4***	23.6
	Malawi (n=5848)	6629.1	9106.9**	84266.7***	7091.5***	190.5	793.5***
	Nigeria (n=6276)	2714.1*	14222.9***	38538.4***	2593.1***	736.7***	520.1***
	Tanzania (n=4722)	2.92e+04*	1588.1	79363.2**	88082.1**	1.1e+04*	298.7
Log per capita consumption expenditure	Ethiopia (n=6794)	0.041	0.181***	0.323***	-0.05***	0.029	0.065**
	Malawi (n=5848)	0.032***	0.054**	0.250**	0.124***	0.017***	0.047***
	Nigeria (n=6276)	0.056	0.147***	0.295***	-0.033*	0.012***	-0.014***
	Tanzania (n=4722)	0.227***	0.441*	0.490**	0.265***	0.048*	-0.025**
Poverty	Ethiopia (n=6794)	-0.266*	-0.400***	-0.754***	-0.067***	-0.01	-0.049***
	Malawi (n=5848)	-0.146	-0.205**	-0.533**	-0.278**	-0.014**	-0.156***
	Nigeria (n=6276)	-0.246***	-0.862***	-1.078***	-0.388**	-0.27***	0.038
	Tanzania (n=4722)	-0.200	-0.539***	-0.652***	-0.293**	-0.24***	-0.097***

Notes: The models were estimated using Maximum Simulated Likelihood with 1000 draws.
***, **,* represent 1%, 5%, and 10% significance level respectively.
Source: author's compilation.