Education Accelerating the Agricultural Transition: Panel Data Analysis of Rural Mexico *Draft*

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Abstract

A critical stage in economic development is the structural shift from a primarily agricultural economy to non-agricultural. This shift is currently underway in rural Mexico. Simultaneously, the national government is investing in building secondary schools in rural communities. I use exogenous shifts in access to secondary schools as an instrumental variable with a differences-in-differences approach to identify the marginal impact of a year of education on the probability of working in agriculture and the probability of migrating as an adult. I find that an additional year of education reduces the probability of working in agriculture at age 20 by 4.9 percentage points on average, and the magnitude of the impact increases as workers age up to 7 percentage points at age 30. An additional year of school is associated with a 0.5 percentage point increase in the probability of working away from home all year in the naive OLS regression, but the results are not significant in the IV specification. These findings show that investing in education can accelerate the transition of labor out of agricultural, which likely has important welfare-improving effects at the individual and household level. However, I do not find significant impacts of education on labor mobility.

Expanding job opportunities outside of the agricultural sector is critical for improving earnings and other welfare outcomes, and in many rural developing economies restricted access to education is likely an important limiting factor to obtaining non-farm work. Understanding the impacts of education on labor sector decisions is an important component to learn how policies can help alleviate poverty. Education is often believed to be an essential element to economic growth (Nelson and Phelps, 1966; Mincer, 1984; Barro, 1992; Becker, Murphy and Tamura, 1994; Benhabib and Spiegel, 1994), but there is little research to identify its role in the agricultural transition. Understanding labor sector decisions is critical, not only for investigating the role of education on individual and household welfare, but also for preparing an economy's smooth transition from primarily agriculture to non-agriculture. In this paper I investigate the impact of education on the transition of labor out of agriculture in rural Mexico. I find that access to secondary schools in rural Mexico decreases the probability of working in agriculture. I do not find significant evidence that education increases the probability of urban migration. The findings suggest that national agendas to improve rural education can accelerate the agricultural transition. This has important implications for the farm sector, which must adjust to a smaller farm labor supply, and it has important implications for employees from rural areas as they gain access to better-paying work. However, the impact of educational policies on poverty alleviation may be limited if they are not accompanied by policies to improve labor mobility or to connect rural residences to urban markets.

Understanding the effect of education on labor sector decisions and migration can guide policy by identifying potential mechanisms by which education enhances earnings and welfare. Several studies show that access to non-farm work is associated with higher incomes and less income variability (Huffman, 1980; Janvry and Sadoulet, 2001; Zhang, Huang and Rozelle, 2002). I use a unique dataset that is nationally representative of rural Mexico to identify the marginal impact of a year of education on the probability of working in agriculture to show that improving supply of secondary education in rural areas can expand work opportunities outside of agriculture. I also look at the impact of education on migration to predict whether there is more rural-urban migration as education rises.

Rural Mexico provides a timely setting for analysis because the rural labor force is currently transitioning out of the farm sector while school provision is expanding. Taylor, Charlton and Yúnez-Naude (2012) show that the farm labor supply from rural Mexico declined between years 2002 and 2010. At the same time the Mexican government has committed to improving access to schools in rural communities. Public spending on education increased by 36 percentage points between 1995 and 2001 (Santibañes, Vernez and Razquin, 2005). Household survey data from rural Mexico record where every household member and every child of the household head works between 1980 and 2010 and their education level. I create an instrument that proxies for village-level access to secondary education when individuals are 12 years old to identify the impacts of education on the probability of working in agriculture or migrating to work away from home when 20 years old. I repeat the analysis for ages 25 and 30 to see whether the effects of education grow or diminish with age.

Several studies find a positive correlation between education and employment in off-farm work (Zhang, Huang and Rozelle, 2002; Huffman, 1980; Janvry and Sadoulet, 2001), but these studies do not account for the potential endogeneity of education in the labor choice model. Duflo (2000) and Foster and Rosenzweig (1996) use school construction as an instrument to identify the impacts of education on income, but they do not distinguish between farm and non-farm labor. Joliffe (2004) measures the marginal returns to education and makes a clear distinction between the farm and non-farm sectors. However, Joliffe examines self-selected education only and does not investigate how changes in the supply of education affect labor allocation.

I contribute to two families of literature, regarding the outcomes of education on labor sector selection and migration and regarding the transition of rural developing economies out of agriculture. I use work outcomes at age 20, and I further investigate results for ages 25 and 30. I look at whether individuals work in the farm sector, whether they migrate within Mexico, and whether they migrate to the United States. I address omitted variables bias and endogeneity in years of education by using village-level changes in access to secondary schools as an instrument. I proxy for changes in school access using sustained changes in school enrollment rates. Village-level changes in school access provide good instruments for education because rural communities have little influence over when and where schools are built. Improvements in access to education predict changes in the expected years of education for individuals of different ages living in the same community.

I find that an additional year of education around secondary school age reduces the probability of working in agriculture at age 20 by 4.9 percentage points. This impact increases with age to over 7 percentage points by age 30. Regressing migration directly on own education shows a significant positive correlation, but the coefficient on education is not significant when I instrument for education using school supply. These findings provide evidence that improving the supply of education in rural areas can improve individual and household welfare by expanding labor opportunities across sectors. These findings have important implications for employees who remain in the farm sector as well as those who transition out of agriculture. In general equilibrium, the farm wages are expected to rise in response to a contraction of farm labor supply. The industry can adjust to the inward shift of labor supply by investing in technologies that employ higher levels of human capital, thus raising the returns to education in farm work, the marginal productivity of workers, and ultimately farm worker wages. When the agricultural transition occurs smoothly, both industry and employees are expected to benefit.

The paper is organized as follows. In Section I, I describe rural Mexico, including changes in the workforce and access to education. In Section II, I describe a theoretical model of the impacts of education on labor allocation between the farm and non-farm sectors. Section III describes the data and Section IV the empirical model. Section V presents the results. Section VI conducts several robustness checks. Section VII discusses the implications of the findings and Section VIII concludes.

I. The Workforce and Access to Education in Rural Mexico

Rural Mexico has entered a stage of development when the workforce is transitioning out of agriculture. The farm work force from rural Mexico fell by 2 million, or 25 percent, between 1995 and 2010 (Charlton and Taylor, 2013). Simultaneously, access to education in rural Mexico is improving. Mexico's constitution requires that basic education (currently grades 1-9) must be publicly available, free of charge, and non-religious. However, access and quality of education vary across communities and across time, and many students do not have access to basic education.

Mexico has invested substantially in education the past few decades, creating exogenous changes in education within communities, but school spending still lags far behind most OECD countries. This indicates that educational improvement is in progress in rural Mexico and not yet complete. Public spending on education rose from 2.9 percent of the GNP in 1980 to 5.1 percent in 2010.[1] Arguably, much of the funding does not benefit the students. About 90 percent of the budget went towards teacher salaries, according to a 2005 report, and in some states, as much as 98 percent. Teacher unions are strong in Mexico and salaries remain high even where teacher absenteeism is common and quality of teaching is low. In the states of Guerrero and Oaxaca, teachers were in the classroom only about 50 percent of school days and on days when teachers were present, school hours were usually reduced by 2 to 3 hours (Santibañes, Vernez and Razquin, 2005).

School funding is highly centralized, so communities have little power to initiate a school-building project on their own. Most school funding is from the central government agency Secretaría de Educación Pública (SEP). In 1992, the education system was decentralized to the 32 states and mandatory education was increased from the completion of primary school (grade 6) to the completion of lower-secondary school (grade 9)[2] (Rolwing, 2006). Although federally required education changed at this time, the mandate was not effectively enforced, particularly in rural Mexico, so the mandate does not provide an exogenous change in expected eduction. The decentralization in 1992

[1] http://databank.worldbank.org/data/home.aspx

[2] I refer to lower-secondary schools as "secondary" schools in the remainder of the paper

was mostly administrative,[3] and despite federal mandates, many children still do not complete secondary school. In 1997, SEP mandated that federal financial resources be distributed to states based on the number of schools and teachers that were decentralized in 1992. However, in 1992, many state schools operated side by side with federal schools. Consequently, states that gathered local funding for education may receive less federal support per pupil even though the demand for schools is high. Currently, the national government provides about 85 percent of educational funding and there is no federal incentive to raise local support or to improve school quality since federal funding cannot be adjusted (Santibañes, Vernez and Razquin, 2005).

Access to education varies across communities and the year that a community obtains a new school is arguably exogenous to other community trends that may impact the decision to work in agriculture. The federal government prioritizes building schools in communities located farthest from existing schools and those with the highest poverty rates. Many communities lack access to schools for many years before the government builds a school, in part, because it is difficult to find qualified teachers to work in rural communities. Conversations in the field reveal that some children are denied access to the local school because of their ethnicity or religion. Physical obstructions, such as a washed out bridge, may prevent children from attending school in a nearby town. States and municipalities can build schools, but they often lack the resources and they may not prioritize rural communities with little political leverage.

Mexico has implemented programs to expand education more quickly. Finding teachers willing to move to rural areas is one of the major constraints in educational supply apart from school infrastructure. Limited supply of teachers and school infrastructure has been resolved in part by multi-shifting schools (providing morning, afternoon, and evening sessions) so that more students can attend school without building additional infrastructure. A system of telesecundarias, or distance learning, was implemented in the 1990s. In telesecundarias, one teacher is hired to teach all of the subjects and students

[3]For example, all primary schools must use national curriculum and nationally produced books and secondary schools must receive approval from SEP for their curriculum and they must select from a list of approved books. Principals and parents do not have the authority to hire, fire, or place teachers.

watch their lessons on satellite television. Telesecundarias are most prevalent in poorer, highly rural states and student test scores tend to be lower in these schools, though other factors may be responsible for this performance gap.

Other government programs are designed to expand education by reducing the cost of attending school for individual families. For example, Oportunidades, the well-known anti-poverty program, gives cash transfers to families conditional on children's school attendance and regular health check-ups. Oportunidades (formerly called Progresa) began in 1997. It was initially offered only to households in randomly selected villages for impact evaluation. Since finding a significant impact on school enrollment, the program became nationally available for qualified households.[4] The program was implemented using a random roll-out design and studies indicate that the program was effective at both targeting the poorest families and at increasing school attainment (Skoufias, Davis and De La Vega, 2001; Schultz, 2004). Progresa was rolled out randomly across villages, so the impacts of Progresa on school attendance should not confound the results in this study.

Several studies indicate that improved access to education has positive impacts on years of school attendance (Duflo, 2000; Foster and Rosenzweig, 1996; Kane and Rouse, 1995; Card, 1993). Lavy (1996) observes that access to secondary education may affect primary schooling decisions as well, and Handa (2002) shows that effects of improved education persist across generations since more educated parents are more likely to send their children to school for more years. Bobonis and Finan (2009) and Lalive and Cattaneo (2009) find that Oportunidades recipients in Mexico positively affect the school attendance of children in their communities who are ineligible for conditional cash transfers. Since communities cannot control or predict the year that a school is built or access improved, access to secondary education provides a good instrument for education. I expect improved access to school to increase the average years of school attended.

The existing literature suggests that the effects of education can be extensive, reaching across peer groups and from one generation to the next. Accessibility of school is an

[4] Since Oportunidades is a welfare program to fight poverty, qualification is targeted to the poor.

important factor in determining years of education, and education is shown to have large impacts on raising incomes. I focus on the impacts of education on labor sector decisions and migration, which are important determinants of income and other welfare outcomes.

II. The Model

II - 1 Take education as exogenously given

To illustrate how education affects the allocation of household labor between the farm and non-farm sectors, consider a utility maximizing household model. I use a household model since labor and migration decisions are often made at the household level to maximize household utility. In this simplified static model without risk or uncertainty, the model can easily be adapted to individual labor decisions rather than the household. Assume that households maximize utility by selecting where to allocate labor, and suppose that households maximize utility by maximizing net income. Households solve

$$\begin{aligned} \max\{y_f(E, L_f, X_f, p_f) + y_n(E, L_n, X_n, p_n)\} \\ s.t. \bar{L} \geq L_f + L_n + E \\ L_f \geq 0 \\ L_n \geq 0 \\ E \geq 0 \end{aligned}$$

where y_f is the household's farm income net input costs and y_n is the household's non-farm income net the costs of inputs. E is the years of education the household attains, L_f is the amount of labor allocated to farm work and L_n the amount of labor allocated to non-farm work, X_s is the productive inputs for sector s (farm or non-farm), and p_s is the vector of prices for sector s. Let sector inputs X_s and prices p_s be given. Each household is endowed with time $\bar{L}$ which can be allocated between farm work, non-farm work, and going to school. For the time being, I will consider education as exogenously given to see how changes in education affect the labor supply decisions. I will relax that assumption later.

The production functions are quasi-concave, and education and labor are complements in production. That is

$$\frac{\partial y_s}{\partial L_s} > 0$$
$$\frac{\partial^2 y_s}{\partial L_s^2} < 0$$
$$\frac{\partial^2 y_s}{\partial L_s \partial E} > 0$$

Since income is monotonically increasing in labor supplied, the time constraint is binding. Assume that non-negativity constraints are not binding so that I can find the impacts of exogenous changes in education on labor allocation across sectors. The objective function can be rewritten as

$$\max_{L_f}\{y_f(E, L_f, X_f, p_f) + y_n(E, \bar{L} - L_f - E, X_n, p_n)\}$$

Households maximize the objective function with respect to the amount of labor allocated to farm work, L_f. Let Q be the objective function. The First Order Conditions are

$$\frac{\partial Q}{\partial L_f} = \frac{\partial y_f}{\partial L_f} - \frac{\partial y_n}{\partial L_n} = 0$$

The First Order Conditions can be rewritten

$$\frac{\partial y_f}{\partial L_f} = \frac{\partial y_n}{\partial L_n}$$

That is, in equilibrium, the marginal benefit of farm labor is equal to its marginal cost in terms of lost labor in the non-farm sector.

Using the Implicit Function Theorem, I find how exogenous changes in education affect the household's allocation of labor to the farm sector.

$$\frac{\partial L_f}{\partial E} = -\frac{\frac{\partial^2 y_f}{\partial L_f \partial E} - \frac{\partial^2 y_n}{\partial L_n \partial E}}{\frac{\partial^2 y_f}{\partial L_f^2} + \frac{\partial^2 y_n}{\partial L_n^2}}$$

The sign of the expression is not certain a priori. The denominator is less than zero by diminishing marginal returns to labor in production. The sign of the numerator depends on the relative complementarity of education to labor in the farm and non-farm sectors. Households will allocate less labor to farm work as education increases if

$$\frac{\partial^2 y_n}{\partial L_n \partial E} > \frac{\partial^2 y_f}{\partial L_f \partial E}$$

That is, as education rises, households will reduce the allocation of labor to the farm sector and increase labor to the non-farm sector if the marginal gains of education to labor productivity in the non-farm sector is greater than the marginal gains of education to labor productivity in the farm sector. I expect that labor and education have greater complementarity in the non-farm sector than in the farm sector (Joliffe, 2004). Then gains in education are expected to reduce allocation to the non-farm sector.

II - 2 Endogenous Education

The analysis above assumes that education is given. However, this assumption is not realistic since education is endogenously determined. I now consider how construction of schools, located closer to the household might cause exogenous changes in education. I introduce a new term to the household's objective function. Let czE be the cost of traveling to and from school, where c is the per kilometer cost of travel, and z is the distance traveled. Assume that everyone attends some school so that the non-negativity constraint on years of education is non-binding. Households solve

$$\max_{L_f, L_n, E} \{y_f(E, L_f, X_f, p_f) + y_n(E, \bar{L} - L_f - E, X_n, p_n) - czE\}$$

The First Order Conditions are

$$\frac{\partial Q}{\partial L_f} = \frac{\partial y_f}{\partial L_f} - \frac{\partial y_n}{\partial L_n} = 0$$
$$\frac{\partial Q}{\partial E} = \frac{\partial y_f}{\partial E} + \frac{\partial y_n}{\partial E} - cz = 0$$

which can be rewritten as

$$\frac{\partial y_f}{\partial L_f} = \frac{\partial y_n}{\partial L_n}$$
$$\frac{\partial y_f}{\partial E} + \frac{\partial y_n}{\partial E} = cz$$

Written in this way, it is clear that at the equilibrium, the marginal productivity of farm work is equal to the marginal productivity of non-farm work, and the marginal benefit to education in terms of increased labor productivity, is equal to the marginal cost of attending school.

Now I consider what happens to education, E, and the amount of labor supplied to the farm sector, L_f, when a new school is constructed such that z decreases. I create the Jacobian matrix from the First Order Conditions and apply the Implicit Function Theorem. The Jacobian is

$$\begin{pmatrix} \frac{\partial^2 y_f}{\partial L_f^2} + \frac{\partial^2 y_n}{\partial L_n^2} & \frac{\partial^2 y_f}{\partial L_f \partial E} - \frac{\partial^2 y_n}{\partial L_n \partial E} \\ \frac{\partial^2 y_f}{\partial L_f \partial E} - \frac{\partial^2 y_n}{\partial L_n \partial E} & \frac{\partial^2 y_f}{\partial E^2} + \frac{\partial^2 y_n}{\partial E^2} \end{pmatrix}$$

The determinant of the Jacobian does not reduce into small terms, so I refer to it as $|J|$. $|J| > 0$ by the quasi-concavity of the production function.

It follows that

$$\frac{dE}{dz} = \frac{c(\frac{\partial^2 y_f}{\partial L_f^2} + \frac{\partial^2 y_n}{\partial L_n^2})}{|J|}$$

and $\frac{dE}{dz} < 0$. This means that as distance to school decreases, the household invests more in education.

Next, I see how labor allocation is expected to change with respect to distance to school.

$$\frac{dL_f}{dz} = \frac{c(\frac{\partial^2 y_f}{\partial L_f \partial E} - \frac{\partial^2 y_n}{\partial L_n \partial E})}{|J|}$$

If $\frac{\partial^2 y_n}{\partial L_n \partial E} < \frac{\partial^2 y_f}{\partial L_f \partial E}$ then $\frac{dL_f}{dz} < 0$,which is the same condition I found for farm labor to decrease in response to exogenous increases in education. If the complementarity of education to non-farm labor is greater than the complementarity of education and farm labor, then household labor allocated to farm work is expected to decline when new schools are constructed close to the home.

This model illustrates that building schools close to children's homes can reduce the farm labor supply in rural areas where traveling to school has traditionally been more costly. The critical assumption is that the returns to education are higher in the non-agricultural sector than in the agricultural sector.

III. Data

I use data from a nationally representative sample of rural Mexican households. The Mexico National Rural Household Survey (Spanish acronym *ENHRUM*[5]) is unique in providing retrospective panel data on individual migration from rural Mexico to both the United States and destinations within Mexico in 1980-2010.

The map in Figure 1 shows Mexico divided into five representative regions and the locations of the original ENHRUM surveys. [6]

Figure 1

The panel data come from three survey rounds: 2002, 2007, and 2010. Each round collects detailed information on migration destinations, whether migrants worked in the agricultural or non-agricultural sector, and employment status (wage-earner or self-employed)

[5] *Encuesta Nacional a Hogares Rurales de México*; Spanish acronym ENHRUM

[6] The surveys in region "Noreste" were dropped from the 2010 survey, so I do not have data for households in this region for years 2008-2010. Some of the original localities shown in the map were dropped in the final survey round due to budget constraints or violence. The remaining sample was randomly selected to retain the integrity of national representation.

for family members, including the household head, his/her spouse, all others living in the household, and children of the household head and spouse living outside the household. Work histories were gathered as far back as 1980 for a randomly selected group of household members and back to 1990 for all household members. Since those who do not have a work history from 1980-1990 are a random sample, the exclusion of these individuals in the earliest decade of the analysis should have no bearing on the results. Some households were dropped from the survey in 2010 due to budget constraints and increased violence in certain communities. The method of dropping communities from the survey in 2010 maintains a nationally representative sample of rural Mexico. The number of individuals at age 20, households, and communities by survey work history period are recorded in Table 1.

Table 1. Number of observations in each ENHRUM survey round

Years	Individuals (age 20)	Households	Communities
1980-2002	3,677	1,539	80
2003-2007	1,061	661	80
2008-2010	376	302	45

The first dependent variable of interest is a dummy variable equal to 1 if the individual works in agriculture at age 20. Each year, the survey records the primary sector that every household member works in for each of three locations: in the home community, migrated to another location within Mexico, and migrated to the United States. If the individual works primarily in the agricultural sector in any one of these three locations when he or she is 20 years old, then the dependent variable will be one.

Additionally, I look at the impact of education on the probability of doing self-employed agricultural work, agricultural wage work, and the probability of migrating. An individual migrates seasonally if he records working outside of his home village, either in Mexico or in the United States, and he also works in his home village when 20 years old. I define full-year migration equal to 1 if an individual reports only working outside of his home village when 20 years old. An individual works in local agriculture if he works in his home village and his primary occupation there is in the agricultural sector. Mexican agriculture refers to individuals who work in a different location in Mexico and work primarily in agriculture in that location. The same definitions apply for the non-agricultural sector in each location and they apply for each sector in the United States.

Since I observe panel data at the village level, each variable varies both within and between villages. I use within village variation to identify the model, so in Table 2, I collapse the data to the village level and then find the overall, within, and between standard deviations. The within variance measures

$s_w^2 = \frac{1}{NT-1}\sum_v \sum_t (x_{iv} - \bar{x_v})^2 = \frac{1}{NT-1}\sum_v \sum_t (x_{iv} - \bar{x_v} + \bar{x})^2$.

The between variance measures $s_b^2 = \frac{1}{N-1}\sum_v (\bar{x_v} - \bar{x})^2$.

The overall variance measures $s_o^2 = \frac{1}{NT-1}\sum_v \sum_t (x_{iv} - \bar{x})^2$.

The minimum and maximum columns in Table 2 measure the minimums and maximums of x_{iv} for overall, $\bar{x_v}$ for between, and $(x_{iv} - \bar{x_v} + \bar{x})$ for within.

The summary statistics in Table 2 show that the mean share of 20 year-olds in a rural Mexican village who work in agriculture is 29.1 percent. Most of them are agricultural wage or salary workers (as opposed to being self-employed). The mean share that work in the non-agricultural sector is 35.9 percent. The remainder do not report working. The overall standard deviation in the share who work in agriculture is 0.361. The standard deviation between villages is 0.176, and the standard deviation within villages is 0.317. A small share of the population migrates outside of their home state for only part of the year (2.5 percent on average). A much larger share works outside of their home state for a full year (18.7 percent on average). Among those who work in their home village, most work in agriculture, and among those who migrate away from home, the majority work in the non-farm sector.

Table 2. Sector and location of work for 20 year-old individuals by village, 1980-2010

VARIABLE		mean	sd	min	max	observations
agriculture	overall	.291	.361	0	1	2,023
	between	.	.176	0	.818	80
	within	.	.317	-.527	1.24	25.3
non-agriculture	overall	.359	.373	0	1	2,023
	between	.	.157	.052	.815	80
	within	.	.338	-.382	1.31	25.3
self-employed agriculture	overall	.114	.248	0	1	2,023
	between	.	.116	0	.516	80
	within	.	.22	-.402	1.07	25.3
agriculture salary workers	overall	.179	.3	0	1	2,023
	between	.	.133	0	.479	80
	within	.	.27	-.3	1.13	25.3
seasonal migration	overall	.025	.114	0	1	2,023
	between	.	.032	0	.16	80
	within	.	.109	-.134	.988	25.3
year-round migration	overall	.187	.3	0	1	2,023
	between	.	.113	.017	.475	80
	within	.	.278	-.288	1.11	25.3
local agriculture	overall	.262	.349	0	1	2,023
	between	.	.168	0	.759	80
	within	.	.307	-.497	1.21	25.3
local non-agriculture	overall	.19	.31	0	1	2,023
	between	.	.163	.004	.808	80
	within	.	.263	-.504	1.13	25.3
agriculture elsewhere in MX	overall	.016	.102	0	1	2,023
	between	.	.03	0	.198	80
	within	.	.098	-.182	.977	25.3
non-agriculture elsewhere in MX	overall	.113	.244	0	1	2,023
	between	.	.099	0	.425	80
	within	.	.223	-.312	1.07	25.3
U.S. agriculture	overall	.019	.103	0	1	2,023
	between	.	.032	0	.191	80
	within	.	.098	-.172	.983	25.3
U.S. non-agriculture	overall	.066	.191	0	1	2,023
	between	.	.093	0	.502	80
	within	.	.17	-.436	1.02	25.3

In addition to work histories, I also observe several individual and household characteristics, including years of education, gender, the number of children (age 14 and under) and the number of working-age adults (ages 15 to 65) living in the individual's household when 12 years old, whether the individual is married, whether the head of the household speaks an indigenous language, and how much land the household inherited as of 2002. These data are summarized in Table 3.

Table 3. Summary of individual and household characteristics

VARIABLE	mean	sd	min	max	obs
years of education	7.78	3.62	0	17	5,114
female	.453	.498	0	1	5,114
children in hh (when age 12)	2.42	2.36	0	11	5,114
adults in hh (when age 12)	2.29	2.74	0	15	5,114
married	.118	.322	0	1	5,114
indigenous language (hh head)	.139	.346	0	1	4,677
inherited land (tens of ha)	.165	1.77	0	50.7	5,114

The mean years of education in the full sample is 7.78. However, years of education differs substantially across generations, the younger generations being more highly educated than the older generations on average. Table 4 shows the years of education by age in 2010. Individuals in their twenties have expected education of 9 years while those in their fifties have expected education of only 5 years. This is an impressive rise in education in a short period of time, and it reflects the rise in secondary education between 1970 and 2000.

One of the factors that likely prevents many children from attending more years of school is poor access to schools. Many children in rural Mexico have to travel to other locations to attend school, which entails high costs for many families. Table 5 shows where

Table 4. Years of education by age in 2010

Age in 2010	Mean	sd	Min	Max	Obs
20-29	8.94	3.42	0	17	1,320
30-39	7.74	3.67	0	21	1,314
40-49	6.58	3.96	0	18	996
50-59	5.04	3.65	0	19	614

students in ENHRUM villages, sorted by level of education, attended school in 2010.[7] It shows whether they attended school in their home village, elsewhere in Mexico, or in the United States. As expected, as students advance in their studies, a much greater share travel to other locations to attend school. As the distance to school increases, attending school becomes more costly, both in the expense of travel and in the opportunity cost of time. Table 6 records the annual expenses families reported paying for transportation to schools elsewhere in Mexico in 2010.[8] The interpretation of these data are limited since they do not include the amounts that extra-marginal families would have paid to send their children to school, the budget constraints of households, or the opportunity costs of time, and the opportunity cost of time might be especially high for older children. However, these summary statistics suggest that distance to school may be an important factor determining years of education, as suggested by the theoretical model in Section III.

Table 5. Where students attended school in 2010 by education level

Type of School		Local	Elsewhere in Mexico	U.S.	Total
Primary	frequency	18,135	1,550	124	19,809
	percentage	91.55	7.82	0.63	100
Lower-secondary	frequency	6,386	3,534	124	10,044
	percentage	63.58	35.19	1.23	100
Upper-secondary	frequency	1,674	3,565	155	5,394
	percentage	31.03	66.09	2.87	100

[7]Upper-secondary school refers to grades 10-11, 12, or 13 depending on the program.

[8]To put these expenses in context, the national mean daily minimum wage in Mexico in 2010 was 56 pesos.

Table 6. Mean cost of school transportation in 2010 if school is located outside of home village (2010 pesos)

Type of School	mean cost	sd	minimum	maximum	observations
Primary	64.89	74.08	0	345.17	1,271
Lower-secondary	92.67	106.55	0	690.34	3,410
Upper-secondary	144.38	262.99	0	2,157.32	3,410

This study identifies the impact of an additional year of school on the probability of working in agriculture. Regressing the dependent variable directly on own education, omitted variables are expected to bias the coefficient on education. Including village fixed effects will control for any unobservable location-specific factors. However, education is self-selected, so this is not expected to control for all unobservables. For example, someone who plans to work in the non-farm sector may choose to attend more years of school because it will help him obtain non-farm work, biasing the coefficient on education downwards (assuming that the coefficient is negative). On the other hand, families may require their most skilled children to begin working to support the household before they finish school. The opportunity cost of attending school for these children would be particularly high so they do not attend, and the potential benefit of attending school is also higher than most children because they are hard workers. This would bias the coefficient on education towards zero. Likewise, if wealthier families own more land and send their children to school for more years while their poorer neighbors, who have little land and take their children out of school to work, then wealthy children may be more likely to attend more years of school and manage their family's farm, biasing the coefficient towards zero. This shows that the sign of the bias is unknown ex-ante and an exogenous change in education is needed to isolate the variation of interest. I use changes in access to schools within villages as an instrument.

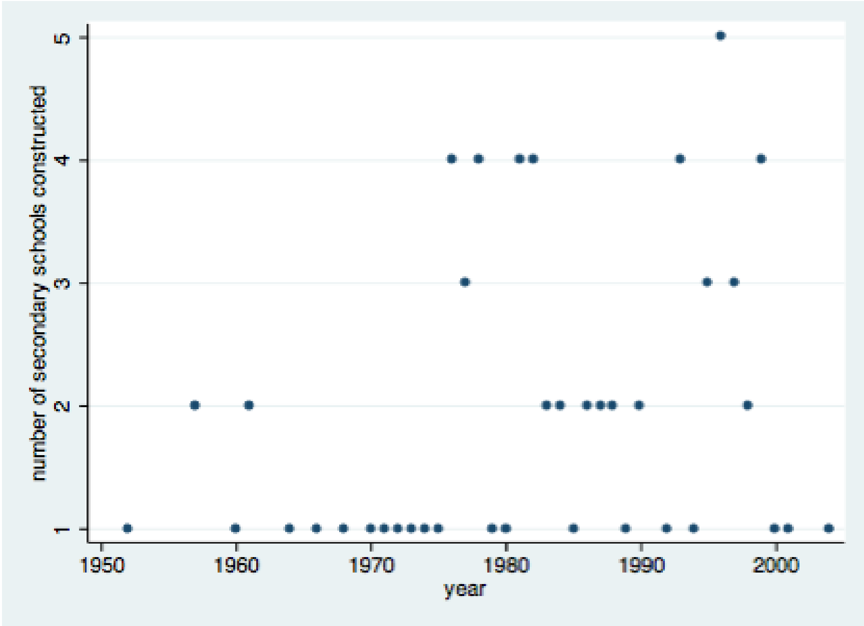
I create a proxy for school access using annual village-level enrollment rates of 12 year-old children recorded in the ENHRUM surveys each year. This is the age when children typically begin secondary school. I use sustained increases in the school enrollment rates in a village as an indicator that the village acquired access to a secondary school, likely through school construction or provision of a qualified teacher. Since education is traditionally low in these rural villages, qualified teachers are unlikely to come from within the village so this still provides exogenous change in school provision. School enrollment rates are calculated by the percentage of 12 year-old children who enroll in secondary school each year. When, for 4 consecutive years, at least 50 percent of children aged 12 attend school, then I assume that the village gained access to secondary school in the first of the 4 years. In some village-years there are no 12 year-old children in the sample (or the education of the 12 year-old children are missing). Therefore, I allow for up to 2 missing values within the stretch of consecutive years with sustained enrollment rates. If I do not observe a change in school enrollment rates for a village, then I assume that the village did not receive access to a secondary school before 2010. Table 7 summarizes the number of 12 year-old children with education data by village-year for years 1970 through 2010. There are 2.5 children per village-year on average with a range from 0 to 11.

Table 7. Mean number of 12 year-olds per village-year (years 1970 through 2010)

	mean	sd	minimum	maximum	observations
Number of 12 year-olds	2.53	1.76	0	11	3,175

Figure 3 graphs the number of villages where I observe changes in access to secondary schools each year based on the proxy described. I will refer to gains in access to school as school construction, assuming that most gains come from school construction. Each dot represents construction of secondary schools in a given year. I can observe the individual work choices at age 20 of individuals with access to secondary school if their village gained school access no later than 2002.

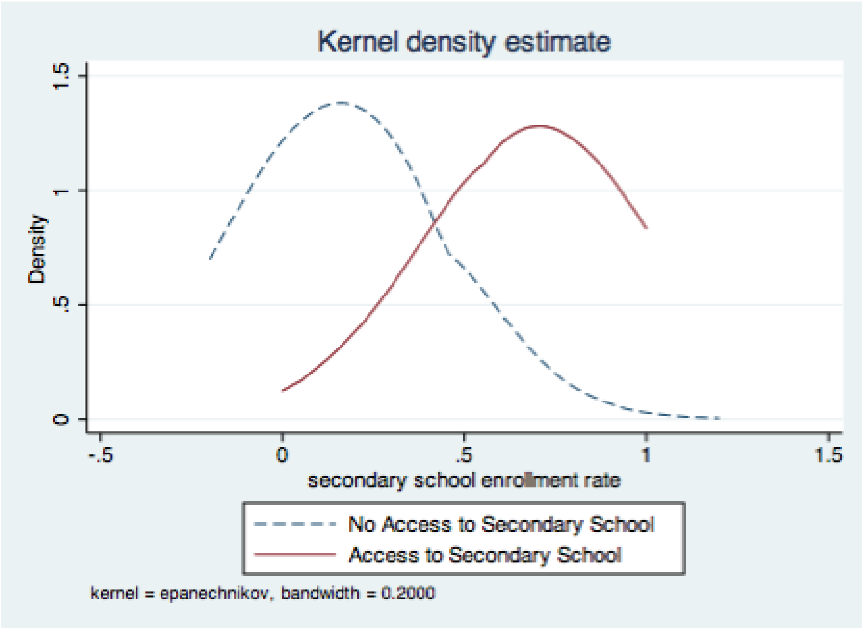
Figure 3. Number of villages that gained secondary school access each year



If observed changes in enrollment rates are a good proxy for school construction, then there should be sustained improvements in school enrollment rates in all years after the proxy turns one. I do find that the school enrollment rates are significantly higher in subsequent years to the switch. Figure 4 shows the kernel densities of secondary school enrollment rates before and after the proxy turns 1. There is a marked improvement in school enrollment rates in years after the proxy indicates that a school was constructed, providing support that the proxy captures changes in school supply.

Figure 5 demonstrates the correlation between school construction and mean years of education. Expected years of education are rising in years before and after schools are constructed. The x-axis in Figure 5 indicates how many years after a school is constructed that the individual turns school age. Negative numbers indicate that the individual is too old to benefit from the school construction. The mean years of education jump upwards for the cohort that becomes school age in the year of school construction to around 9 years of school, or the completion of lower-secondary school.

Figure 4. Kernel Density of secondary school enrollment rates by proxy for access to secondary school



IV. Empirical Approach

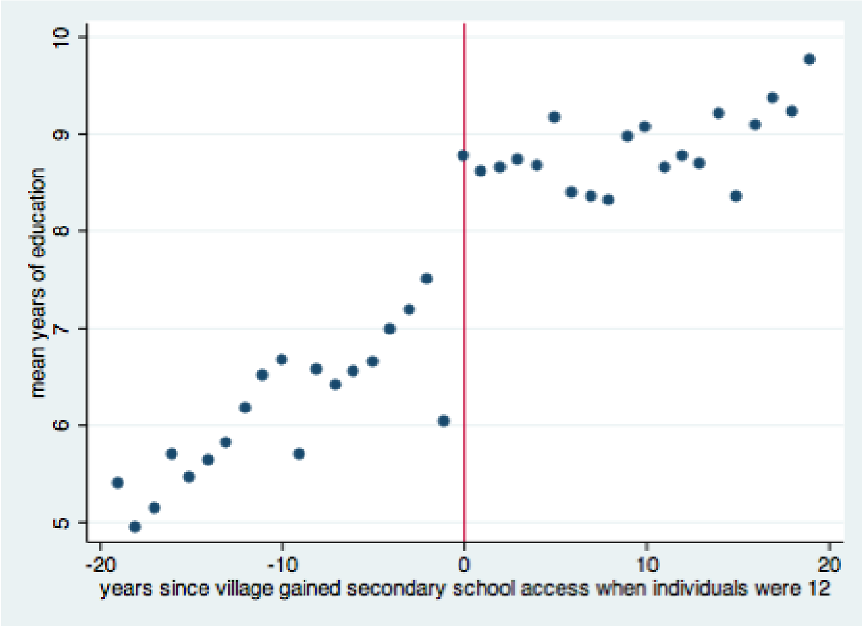
Many studies have attempted to measure the impacts of individual education on labor outcomes. Identification in these models is complicated by several empirical challenges.

The simplest, reduced form model regresses the outcome, whether an individual works in agriculture at age 20 on a constant and years of education. Let $Y_{i,v,t}$ be the outcome of interest. To begin, let $Y_{i,v,t}$ equal 1 if individual i from village v works in agriculture in year t, that is when he is 20 years old, and zero otherwise. Let edu_i be the years of education that i has attained.

$$Y_{i,v,t} = \gamma + \beta edu_i + \epsilon_{i,v,t}, \tag{1}$$

The coefficient β is expected to give biased and inconsistent estimates for the impact of education on the probability of working in the farm sector. Both education and work sector are self-selected variables and there are many unobservable variables likely to impact both. I can control for observed characteristics, X_i, including gender, how many children and adults lived in i's household when he was school-age, whether i is married, and how much agricultural land i's household has inherited. However, I expect that the

Figure 5. Mean years of education for individuals who turned 12 before and after their village gained access to secondary school



location of one's home village also influences how many years i attends school and where i works as an adult. Children from villages that are better connected to urban centers likely have better access to schools and better access to non-farm jobs. I can control for unobserved, time-invariant village characteristics by including village fixed effects, λ_v, as in Equation (2).

$$Y_{i,v,t} = \alpha + \beta edu_i + \gamma X_i + \lambda_v + \epsilon_{i,v,t} \tag{2}$$

The coefficient in Equation (2) will still be biased if there are omitted variables that change over time, correlated with both education and sector selection. For example, government policies to increase mandatory years of education followed by an increase in non-farm GDP might lead to increases in both years of education and the probability of working in the non-farm sector, but the correlation is spurious. To control for simultaneous shocks, I control for year fixed effects, ϕ_t. This is similar to the differences-in-differences estimator (DD). The DD estimator measures the variation of outcomes within villages where years of education rose (or fell) relative to villages where education remained constant.

$$Y_{i,v,t} = \alpha + \beta edu_i + \lambda_v + \phi_t + \epsilon_{i,v,t} \tag{3}$$

The key assumption for DD is that education and sector choice trends would be the same across all villages absent of treatment (that is absent any changes in education within villages). However, this does not seem like a realistic assumption since I expect that trends differ across villages. Labor may transition out of agriculture more quickly in villages that are located closer to industrial centers or that have stronger migrant networks, for example. I therefore control for differences in trends across villages by controlling for village-specific trends, $\lambda_v t$.

$$Y_{i,v,t} = \alpha + \beta edu_i + \lambda_v + \phi_t + \lambda_v t + \epsilon_{i,v,t} \tag{4}$$

If, after controlling for observable characteristics, village fixed effects, year fixed effects, and village trends, i's education is as good as random, then Equation (4) will measure consistent, unbiased estimates of the expected impact of an additional year of education on labor outcomes. However, even within villages, I expect that innate ability and other unobservable individual characteristics influence years of education and labor sector outcomes. I address this concern by using exogenous changes in supply of education within villages. Let D_i be a dummy variable equal to 1 if i's village had secondary school access when i was 12 years old and 0 otherwise. I can regress the outcome directly on D_i to find the impact of having access to secondary school as a child on the probability of working in agriculture as an adult. Since individuals and their families cannot determine the year that schools are constructed in their villages, D_i generates exogenous changes in expected years of education.

$$Y_{i,v,t} = \alpha + \beta D_i + \lambda_v + \phi_t + \lambda_v t + \epsilon_{i,v,t} \tag{5}$$

Equation (5) shows the impact of having local access to secondary education on the outcome of interest (working in agriculture or migrating). To find the marginal impact of a year of education, I use school access as an instrument for education. The first stage estimates Equation 5 where years of education is the dependent variable. The second stage estimates Equation 6 where $\tilde{edu}_i$ refers to the years of education estimated in the first stage, where both stages are estimated simultaneously to adjust for more efficient standard errors.

$$Y_{i,v,t} = \alpha + \beta \tilde{edu}_i + \lambda_v + \phi_t + \lambda_v t + \epsilon_{i,v,t} \tag{6}$$

The coefficient estimated in Equation (6) is expected to yield unbiased, consistent estimates for the marginal impact of a year of education on the probability of working in agriculture.

V. Results

V - 1 Probability of Working in Agriculture Regressed on Own Education

Table 8 reports the results from regressing the dummy for working in agriculture at age 20 directly on own education. The first column includes a constant, years of education, and no additional controls. Column (2) controls for observable individual and household characteristics, including gender, the number of children under age 15 in the household when the individual was 12 years old, the number of adults in the household ages 15 to 65 when the individual was 12 years old, whether the individual is married, and how many hectares of land the household inherited as of 2002 (scaled to tens of hectares). Inclusion of observed characteristics shows no impact on the coefficient for education. However, the additional controls show that women are about 25 percentage points less likely to work in agriculture and those who grow up in households with more younger children are more likely to work in agriculture. Once I control for village and year fixed effects, additional hectares of inherited land are associated with higher probability of working in agriculture. Column (3) includes village fixed effects, column (4) includes year fixed effects, and column (5) includes village-specific trends. After I control for village fixed effects in column (3) the magnitude of the coefficient on years of education shrinks from

-2.2 percentage points to -1.7 percentage points, demonstrating that unobserved time-invariant characteristics of the village are correlated with educational attainment and sector choice. The coefficient changes slightly with the inclusion of year fixed effects and village time trends, but the changes are small and the coefficient remains highly significant. After including village trends in column (5), the model indicates that an additional year of education reduces the probability of working in agriculture by 1.5 percentage points.

Table 8. Probability of working in agriculture regressed on education
Linear Probability Model (Age 20)

VARIABLES	(1) agriculture	(2) agriculture	(3) agriculture Village FE	(4) agriculture Village FE Year FE	(5) agriculture Village FE Year FE Village Trends
years of education	-0.023	-0.022	-0.017	-0.014	-0.015
	(0.003)***	(0.003)***	(0.002)***	(0.002)***	(0.002)***
female		-0.254	-0.259	-0.253	-0.249
		(0.019)***	(0.019)***	(0.019)***	(0.019)***
children in hh		0.007	0.006	0.010	0.010
		(0.004)	(0.004)*	(0.004)**	(0.004)**
adults in hh		-0.002	-0.003	0.001	0.001
		(0.003)	(0.003)	(0.003)	(0.003)
married		0.013	0.030	0.022	0.023
		(0.026)	(0.018)	(0.018)	(0.017)
inherited land (tens of ha)		0.007	0.008	0.008	0.008
		(0.006)	(0.005)	(0.005)*	(0.005)*
Observations	5,114	5,114	5,114	5,114	5,114
R-squared	0.0350	0.115	0.240	0.249	0.268

Robust standard errors in parentheses, clustered at the village level
*** p<0.01, ** p<0.05, * p<0.1

V - 2 Reduced Form: Regress Probability of Working in Agriculture on School Access

The coefficients reported in Table 8 are only consistent if years of education are as good as randomly assigned once I control for village fixed effects, year fixed effects, and village trends. If own education is correlated with individual unobservable characteristics that are not absorbed by the fixed effects or the observable control variables, then the coefficient on education will be inconsistent and biased. In Table 9, I use an exogenous proxy for education, changes in local access to secondary schools. Column (1) regresses the dummy variable for working in agriculture directly on secondary school access with no additional controls. Column (2) includes observable characteristics, and the remaining columns respectively add village fixed effects, year fixed effects, and village-specific trends.

The impact of secondary school construction is not significant when I include year fixed effects. However, it is large and significant after I additionally control for village trends, suggesting that confounding trends mask the effects of secondary school access when I do not control for them. The results show that exogenous gains in access to secondary school when school age reduce the probability of working in agriculture as an adult by 5.4 percentage points.

V - 3 Instrumental Variables: Two-Stage Least Squares

The reduced form regressions in Table 9 suggest that improved access to secondary schools decreases the probability of working in agriculture. The predicted mechanism of the impact is that local construction of secondary schools increases the expected years of education and additional years of education reduce the probability of working in agriculture. To identify the marginal effects of an additional year of education, I use access to secondary schools as an instrument for education.

Table 10 reports the first stage results of the impact of school access on expected

Table 9. Effects of school construction on the probability of working in agriculture
Reduced Form Linear Probability Model (Age 20)

VARIABLES	(1) agriculture	(2) agriculture	(3) agriculture Village FE	(4) agriculture Village FE Year FE	(5) agriculture Village FE Year FE Village Trends
secondary school access	-0.153	-0.144	-0.093	-0.031	-0.054
	(0.030)***	(0.031)***	(0.018)***	(0.023)	(0.023)**
female		-0.255	-0.260	-0.254	-0.251
		(0.020)***	(0.019)***	(0.019)***	(0.019)***
children in hh		0.007	0.007	0.010	0.010
		(0.005)	(0.004)*	(0.004)**	(0.004)**
adults in hh		0.001	-0.002	0.001	0.002
		(0.003)	(0.003)	(0.003)	(0.003)
married		0.028	0.042	0.033	0.033
		(0.025)	(0.019)**	(0.018)*	(0.018)*
inherited land (tens of ha)		0.005	0.007	0.007	0.007
		(0.005)	(0.005)	(0.005)	(0.005)
Observations	5,114	5,114	5,114	5,114	5,114
R-squared	0.0273	0.108	0.229	0.239	0.258

Robust standard errors in parentheses, clustered at the village level
*** p<0.01, ** p<0.05, * p<0.1

years of education. The coefficient on access to secondary schools is highly significant in all specifications. The coefficient becomes smaller with the inclusion of year fixed effects and village-specific trends. This is not surprising since the demand for education is rising throughout Mexico along with expanded supply of schools, leading to spurious correlation if trends are not accounted for. In the final specification I find that local access to secondary school increases the expected years of education by 1.116 years. Since secondary school is 3 years, these findings show that take-up is not complete. Some students choose not to attend school even though a local school is supplied and some students choose not to complete secondary school even though they begin. Still other students attend school in years prior to school construction, further reducing the impact of constructing schools on years of school attended.

Table 10. Effects of school construction on expected years of education

VARIABLES	(1) education	(2) education	(3) education Village FE	(4) education Village FE Year FE	(5) education Village FE Year FE Village Trends
secondary school access	2.763	2.699	2.510	1.259	1.116
	(0.188)***	(0.181)***	(0.160)***	(0.179)***	(0.211)***
female		0.228	0.225	0.111	0.104
		(0.096)**	(0.094)**	(0.094)	(0.097)
children in hh		-0.018	0.023	-0.014	-0.019
		(0.030)	(0.027)	(0.027)	(0.028)
adults in hh		0.019	0.024	-0.030	-0.024
		(0.022)	(0.022)	(0.024)	(0.026)
married		-1.024	-0.871	-0.735	-0.685
		(0.158)***	(0.135)***	(0.142)***	(0.140)***
inherited land (tens of ha)		0.098	0.066	0.068	0.071
		(0.036)***	(0.027)**	(0.027)**	(0.025)***
Observations	5,114	5,114	5,114	5,114	5,114
R-squared	0.141	0.152	0.227	0.258	0.275

Robust standard errors in parentheses, clustered at the village level
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 11 reports the second stage results, instrumenting for education using local access to secondary schools. The results are significant at the 5 percentage level in the specification that controls for village fixed effects, year fixed effects, and village-specific trends. The magnitude of the coefficient decreases when village fixed effects are included, and it rises somewhat in the fifth column compared to column (3). The results indicate that an additional year of school reduces the probability of working in agriculture by 4.9 percentage points.

The coefficient on education is larger in the IV estimate than in the naive OLS regression, and the coefficients on the control variables for individual and household characteristics are similar to those found in the reduced form model.

The test for endogeneity of education using the Durbin-Wu-Hausman test, which allows for heteroskedastic errors, shows that the IV results are significantly different from the naive OLS results. I find an F-statistic of $F(1, 79) = 2.84$ and a corresponding p-value of 0.096. A possible explanation for the large coefficients on education in the IV regressions is that access to secondary school is a weak instrument, causing bias. However, I do not find evidence of a weak instrument when I test the strength of the instrument. In the last column, which includes village and year fixed effects and village trends (and in all columns) the instrument is strong. The first-stage F-statistic in Column (5) is $F(1,79) = 27.887$, which is far above the threshold F-statistic of 10. Since the standard errors in the regression are clustered at the village level, I use Stock and Yogo's test for weak instruments, which adjusts for heteroskedastic standard errors, and I again reject the null hypothesis that the instrument is weak with a high level of confidence. These tests suggest that the large results found in the IV specification are not the product of weak instrumental variable bias.

V - 4 Migration outcomes

Table 12 reports the results from regressing several migration-sector dummy variables on Equation (4). The results show that additional years of education are associated with

Table 11
Effects of education on the probability of working in agriculture at age 20
Instrument for education using access to secondary schools (2SLS)

	(1)	(2)	(3)	(4)	(5)
	agriculture	agriculture	agriculture	agriculture	agriculture
			Village FE	Village FE	Village FE
				Year FE	Year FE
					Village Trends
VARIABLES					
years of education	-0.055	-0.053	-0.037	-0.024	-0.049
	(0.010)***	(0.011)***	(0.007)***	(0.019)	(0.021)**
female		-0.242	-0.252	-0.252	-0.246
		(0.019)***	(0.018)***	(0.018)***	(0.017)***
children in hh		0.006	0.007	0.010	0.009
		(0.004)	(0.004)**	(0.004)***	(0.004)**
adults in hh		0.002	-0.001	0.000	0.001
		(0.003)	(0.003)	(0.003)	(0.003)
married		-0.027	0.010	0.015	-0.000
		(0.026)	(0.020)	(0.024)	(0.025)
inherited land (tens of ha)		0.010	0.010	0.009	0.011
		(0.006)	(0.005)*	(0.005)*	(0.006)*
Observations	5,114	5,114	5,114	5,114	5,114
R-squared	.	0.054	0.219	0.244	0.215
Test for endogeneity of education. H_0: education is exogenous					
F(1,79)	12.83***	10.4811***	8.386***	0.296	2.84*
First-stage F-stats. H_0 secondary=0 using robust standard errors					
F(1,79)	215.661***	222.773***	245.019***	49.547***	27.887***
Stock and Yogo's Test for weak instruments. H_0: instrument is weak					
(The critical value for 2SLS of nominal 5% Wald test rejection of the null at 10% is 16.38)					
min eigenvalue stat	836.35	777.265	362.633	61.230	34.322

Robust standard errors in parentheses, clustered at the village level
*** p<0.01, ** p<0.05, * p<0.1

greater year-round migration (i.e. the individual does not work locally at all during the year), lower probability of working in agriculture either locally or elsewhere in Mexico, and greater probability of working in the non-farm sector elsewhere in Mexico.

Table 13 reports the IV results. The results show that additional years of education reduce the probability of working in the agricultural sector in Mexico (both locally and elsewhere in Mexico), and education increases the probability of doing local non-farm work. I find no evidence that education increases labor mobility once I instrument for education using school access.

The coefficients on the control variables indicate that gender is an important factor determining where one works. Women are less likely to work in any sector and location, and in particular they are less likely to work in the local agricultural sector and they are less likely to migrate year-round than are men. Individuals from homes with more young children when the individual is growing up are significantly more likely to migrate for the full year and they are more likely to work in the local farm sector. Finally, I find that additional hectares of inherited land increase the probability of doing local agricultural work.

Table 12. Regress Migration on Own Education
Linear Probability Model (Age 20)

VARIABLES	(1) migrate seasonally	(2) migrate all year	(3) local ag	(4) local nonag	(5) mx ag	(6) mx non-ag	(7) us ag	(8) us non-ag
years of education	-0.000	0.005	-0.013	0.001	-0.002	0.007	-0.000	-0.001
	(0.001)	(0.002)***	(0.002)***	(0.002)	(0.000)***	(0.002)***	(0.000)	(0.001)
female	-0.032	-0.092	-0.214	-0.003	-0.015	-0.015	-0.030	-0.065
	(0.006)***	(0.015)***	(0.019)***	(0.016)	(0.004)***	(0.012)	(0.007)***	(0.011)***
children in hh	0.000	0.004	0.008	0.010	-0.000	0.003	0.002	-0.000
	(0.001)	(0.004)	(0.004)**	(0.003)***	(0.001)	(0.003)	(0.001)	(0.002)
adults in hh	-0.000	0.010	0.001	0.003	-0.001	0.007	-0.000	0.004
	(0.001)	(0.003)***	(0.003)	(0.002)	(0.001)	(0.003)**	(0.001)	(0.002)**
married	0.007	-0.039	0.021	-0.031	-0.006	-0.020	0.006	-0.011
	(0.007)	(0.017)**	(0.018)	(0.017)*	(0.005)	(0.016)	(0.006)	(0.007)
inherited land (tens of ha)	-0.001	-0.001	0.009	-0.004	-0.001	-0.003	0.000	-0.000
	(0.001)**	(0.003)	(0.005)	(0.006)	(0.000)*	(0.002)	(0.000)	(0.001)
Observations	5,114	5,114	5,114	5,114	5,114	5,114	5,114	5,114
R-squared	0.060	0.142	0.247	0.194	0.078	0.149	0.103	0.154

Village FE, Year FE, and Village Trends included in each regression
Robust standard errors in parentheses, clustered at the village level
*** p<0.01, ** p<0.05, * p<0.1

Table 13. Impact of School Access on Migration at Age 20
Instrument for Education using Local School Access: Linear Probability Model)

VARIABLES	(1) migrate seasonally	(2) migrate all year	(3) local ag	(4) local non-ag	(5) mx ag	(6) mx non-ag	(7) us ag	(8) us non-ag
years of education	-0.005	0.009	-0.047	0.035	-0.010	0.004	-0.000	0.008
	(0.008)	(0.023)	(0.020)**	(0.020)*	(0.005)**	(0.018)	(0.010)	(0.015)
female	-0.032	-0.092	-0.211	-0.007	-0.014	-0.014	-0.030	-0.066
	(0.005)***	(0.015)***	(0.018)***	(0.016)	(0.004)***	(0.012)	(0.007)***	(0.011)***
children in hh	-0.000	0.004	0.008	0.010	-0.000	0.003	0.002	-0.000
	(0.001)	(0.004)	(0.004)*	(0.003)***	(0.001)	(0.003)	(0.001)	(0.002)
adults in hh	-0.000	0.010	0.000	0.004	-0.001	0.007	-0.000	0.004
	(0.001)	(0.003)***	(0.003)	(0.003)	(0.001)	(0.003)***	(0.001)	(0.002)**
married	0.004	-0.036	-0.001	-0.008	-0.011	-0.022	0.006	-0.005
	(0.009)	(0.023)	(0.024)	(0.022)	(0.006)*	(0.021)	(0.010)	(0.013)
inherited land (tens of ha)	-0.001	-0.002	0.011	-0.006	0.000	-0.002	0.000	-0.001
	(0.001)	(0.003)	(0.006)*	(0.006)	(0.001)	(0.002)	(0.001)	(0.001)
Observations	5,114	5,114	5,114	5,114	5,114	5,114	5,114	5,114
R-squared	0.053	0.142	0.193	0.122	0.032	0.148	0.103	0.142

Village FE, Year FE, and Village Trends included in each regression
Robust standard errors in parentheses, clustered at the village level
*** p<0.01, ** p<0.05, * p<0.1

VI. Robustness Checks

VI - 1 Labor decisions at ages 25 and 30

The analysis thus far investigates the labor decisions of adults when they are 20 years old. I now investigate whether these results are robust to labor decisions at older ages. Table 14 shows the results for adults at age 25. All specifications include village fixed effects, year fixed effects, and village-specific trends. Column (1) is the naive OLS regression that regresses the dummy for working in agriculture directly on own education. It shows that an additional year of school is associated with a 1.7 percentage point decrease in the probability of working in agriculture, similar to the results in Table 8 for 20 year-olds. Column (2) shows the results for the reduced form impact of gaining secondary school access on the probability of working in agriculture. The results are significant at the 5 percentage level and they are larger than the results found in Table 9. For 25 year-olds, having local access to secondary school reduces the probability of working in agriculture by 7 percentage points, 2 percentage points more than found for 20 year-olds. Column (3) shows the first-stage results of regressing education on secondary school access. The results differ from those found in Table 10 because the sample is different. I do not observe individuals who turn 20 near the end of the time frame. The impact of school access appears smaller in this sample, but the results are similar in magnitude and significant at the 1 percentage level. Finally, column (4) reports the second stage results for the impact of education on the probability of working in agriculture. An additional year of school reduces the probability of working in agriculture at age 25 by 7.8 percentage points. This impact is quite a bit larger than the impact found for 20 year-olds.

The impact of education on labor outcomes at age 30 is also large. I find that an additional year of school reduces the probability of working in agriculture at age 30 by 7 percentage points and the results are significant at the 1 percentage level. The results are recorded in Table 15.

Table 14
Outcomes at age 25

VARIABLES	(1) agriculture naive OLS	(2) agriculture reduced form	(3) education first stage	(4) agriculture 2SLS
years of education	-0.017			-0.078
	(0.002)***			(0.032)**
secondary school access		-0.070	0.887	
		(0.029)**	(0.224)***	
female	-0.242	-0.239	-0.142	-0.250
	(0.019)***	(0.019)***	(0.105)	(0.018)***
children in hh	0.005	0.005	-0.015	0.004
	(0.004)	(0.004)	(0.035)	(0.004)
adults in hh	0.003	0.003	0.002	0.003
	(0.003)	(0.003)	(0.031)	(0.003)
married	-0.006	-0.003	-0.201	-0.019
	(0.017)	(0.017)	(0.154)	(0.020)
inherited land (tens of ha)	0.004	0.003	0.048	0.007
	(0.002)**	(0.002)*	(0.019)**	(0.003)**
Observations	4,748	4,748	4,749	4,748
R-squared	0.259	0.246	0.276	0.055

Test for endogeneity of education. H_0: education is exogenous

F(1,79) 3.923*

First-stage F-stats. H_0 secondary=0 using robust standard errors

F(1,79) 15.884***

Stock and Yogo's Test for weak instruments. H_0: instrument is weak

(The critical value for 2SLS of nominal 5% Wald test rejection of the null at 10% is 16.38)

min eigenvalue stat 16.263

All specifications include village FE, year FE, and village-specific trends.
Robust standard errors in parentheses, clustered at the village level
*** p<0.01, ** p<0.05, * p<0.1

Table 15
Outcomes at age 30

	(1)	(2)	(3)	(4)
	agriculture	agriculture	education	agriculture
	naive OLS	reduced form	first stage	2SLS
VARIABLES				
years of education	-0.016			-0.070
	(0.002)***			(0.026)***
secondary school access		-0.088	1.256	
		(0.026)***	(0.304)***	
female	-0.233	-0.231	-0.115	-0.239
	(0.018)***	(0.019)***	(0.116)	(0.017)***
children in hh	0.005	0.005	0.003	0.005
	(0.005)	(0.005)	(0.042)	(0.006)
adults in hh	-0.002	-0.002	0.027	-0.000
	(0.004)	(0.004)	(0.040)	(0.004)
married	0.033	0.035	-0.110	0.027
	(0.020)*	(0.020)*	(0.198)	(0.022)
inherited land (tens of ha)	0.011	0.010	0.062	0.014
	(0.004)***	(0.004)**	(0.022)***	(0.005)***
Observations	4,209	4,209	4,209	4,209
R-squared	0.259	0.247	0.294	0.099
Test for endogeneity of education. H_0: education is exogenous				
F(1,79)				6.784**
First-stage F-stats. H_0 secondary=0 using robust standard errors				
F(1,79)				17.11***
Stock and Yogo's Test for weak instruments. H_0: instrument is weak				
(The critical value for 2SLS of nominal 5% Wald test rejection of the null at 10% is 16.38)				
min eigenvalue stat				21

All specifications include village FE, year FE, and village-specific trends.
Robust standard errors in parentheses, clustered at the village level
*** p<0.01, ** p<0.05, * p<0.1

VI - 2 Falsification tests

I regress several pre-determined variables on Equation (5) to test whether access to secondary schools is indicative of other changes in the population. Table 16 reports the results. I find no evidence that access to secondary school is correlated with any systematic changes in the village population except for the impact that it has on the number of adults in the household. However, the impact on the number of adults is intrinsic to the survey design since the survey follows the same households over time and all of the children at the beginning of the survey must grow up while at the same time, schools are being built later in the sample period. For this reason I control for adults in the household in the regressions of interest. The absence of significant impacts in Table 16 supports the model that access to secondary school is correlated with labor outcomes only through its influence on years of education.

Table 16. Balance Tests

VARIABLES	(1) children in hh	(2) adults in hh	(3) married	(4) indigenous lang	(5) inherited land
secondary school access	0.015	0.339	0.012	-0.011	0.041
	(0.127)	(0.178)*	(0.019)	(0.018)	(0.050)
Observations	5,114	5,114	5,114	4,677	5,114
R-squared	0.374	0.316	0.155	0.791	0.0699

Village FE, Year FE, and Village Trends included in each regression
Robust standard errors in parentheses, clustered at the village level
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

VII. Discussion

The findings indicate that rising education does accelerate the agricultural transition of labor away from farm work. I find larger impacts of education on sector selection in the instrumental variables model than in the naive OLS regressions. This finding is not intuitive since more schooling is usually associated with greater innate ability. A possible explanation for the findings in this paper is that the most skilled (or possibly most disciplined) children have the highest opportunity cost of attending school when it is far from home. The most skilled children may be kept from school at a young age because their families need them to work and support the household. For these children the opportunity cost of traveling a long distance to school is high because they could otherwise be working. Being particularly skilled or hard-working, they also have the greatest marginal benefit from gaining access to secondary school. In this scenario, the children denied access to school are those with the greatest marginal benefit of attending school. This would bias the IV estimator downward (greater in magnitude). Then the true effect of education on the probability of working in agriculture would lie somewhere between the naive OLS estimate and the IV estimate.

This finding is consistent with Card (2001)'s observation that IV results are nearly always as large or larger than OLS results in studies that measure the returns to education using exogenous changes in school supply as an instrument for education. Card (2001) suggests that the estimated marginal returns to education using supply to school as an instrument are usually greater than the OLS estimates because the populations that are most affected by the change in school supply are those with higher relative returns to education and high marginal cost of going to school.

Understanding education's role in the agricultural transition has important implications for income, risk, and welfare impacts as well as general equilibrium impacts that may be influenced by policy design. If the returns to education are greater in the non-farm sector than in the farm sector, then policies that reduce the costs of going to school can help individuals to complete more years of school and find higher-paying jobs to help alleviate some of the impacts of poverty. I do find large, significant impacts of education on labor sector selection in both the naive and IV specifications. Although I find significant impacts of education on migration in the naive OLS regressions, I do not find a significant impact of education on migration once I instrument for education using school supply. More investigation might clarify whether there is a causal relationship between education and labor mobility.

Identification in this paper depends on observable changes in school enrollment rates. Additional field work to learn when schools are built across all villages and how children travel to and from school over time can potentially strengthen the analysis. In future work

I plan to investigate how education interacts with variables such as wealth, land-holdings, and gender to impact farm labor decisions and migration.

VIII. Conclusion

The findings in this paper show that policies directed towards improving access to education can accelerate the agricultural transition. This is the case in rural Mexico. The findings show that an additional year of school when a child is beginning secondary school reduces the probability of working in agriculture at age 20 by 4.9 percentage points. The impact appears more dramatic as individuals age. At age 30, I find a negative 7 percentage point impact of an additional year of school on the probability of working in agriculture. Since the children initially denied access to secondary school might also be the children in the population with the greatest marginal benefits from education, the IV estimates on the impact of education might be larger than the average impact of education across the full population in rural Mexico. Nevertheless, results from the naive OLS specifications and the IV specifications confirm that education is a large, significant factor reducing the probability that individuals work in agriculture. I find significant, positive correlation between education and the probability of working away from home in the naive regression but I do not find that additional years of education increase the probability of migration after I instrument for education. This shows that policies to improve access to secondary schools in rural areas decrease the farm labor supply but potentially have no impact on labor mobility.

Much of the previous literature on the economic returns to education shows that both increasing education and obtaining work outside of the agricultural sector are associated with higher incomes and less income variability. This study shows that education is an important factor for individuals in rural communities to gain opportunities outside of the agricultural sector. If obtaining non-agricultural employment leads to higher incomes as much of the literature suggests, then education's impact on labor selection is likely a critical factor for relieving poverty in rural developing economies. The impact might be larger if education increased opportunities for migration as well, but more research is needed to investigate these impacts.

The benefits of education in the agricultural transition are not limited to individuals who find work outside of agriculture. The expected general equilibrium effects of rising education are expected to benefit employees who remain in the agricultural sector as well. As education rises and the supply of farm workers shifts inward, farm wages are expected to rise. In response, the industry will likely invest in technologies to raise the marginal productivity of workers. More technical work in the farming industry can compensate workers for their education and skills. Thus, in the long run, the impact of education on the probability of working in agriculture might begin to diminish.

Individuals with higher education will work in the sector where the returns to education are greatest. Access to secondary education is improving in rural Mexico, and more educated adults are obtaining jobs in industries outside of the agricultural sector where they will be better compensated for their skills. Countries where the farm industry has traditionally employed workers from rural Mexico must take strides to adjust to a more educated population of workers and a more inelastic supply of labor. Such adjustments can benefit the employers by incentivizing the industry to invest in more productive technologies and they are expected to benefit employees by raising their marginal productivity and consequently their wages.

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