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A Declining Farm Workforce: Analysis of Panel Data from Rural Mexico

Diane Charlton and J. Edward Taylor

Analysis of nationally representative individual-level panel data from 1980 to 2010 reveals a significant negative trend in the agricultural labor supply from rural Mexico, which is the primary source of hired workers for U.S. farms. These findings offer an explanation for the rise over time in U.S. farm wages. Concomitants of the agricultural transformation, including growth in the non-farm economy, falling birth rates, and an increase in rural education, accelerate the transition of rural Mexicans out of farm work. Higher U.S. farm wages and increased border enforcement slow the transition, but the combined impact of these offsetting variables is relatively small. A diminishing farm labor supply has far-reaching implications for farmers, farm labor organizers, rural communities, and agricultural workers.

Key words: Agricultural transition, dynamic panel analysis, farm labor, immigration, labor supply, Mexico.

JEL codes: J21, J43, O15, Q12.

Rural Mexico is the primary source of hired labor for U.S. farms (U.S. Department of Labor, Employment and Training Administration 2014). In the twentieth century an elastic supply of labor from rural Mexico enabled labor-intensive fruit, vegetable, and horticultural (FVH) production to expand despite the withdrawal of U.S.-born workers from the hired farm work force (Martin 2003). This elastic labor supply also discouraged labor-saving technological change, created challenges for organizing farm labor, and contributed to the transmission of poverty from rural Mexico to rural America (Martin, Fix, and Taylor 2006; Martin and Taylor 1998). Taylor, Charlton, and Yúnez-Naude (2012), however, found suggestive evidence of a recent negative shift in the farm labor supply from rural Mexico that could not be explained by labor demand shocks during the 2008 recession.

The present article formally tests whether indeed there is a negative trend in the farm labor supply from rural Mexico, and if so, why. Uncovering the factors shaping changes in the farm labor supply is critical to determine whether these changes are transitory and potentially influenced by U.S. immigration reforms or other policies, or whether they are likely to be resilient to policy interventions. Mexico is a particularly compelling empirical study because it supplies farm labor both domestically and to the United States, where the domestic workforce has already transitioned out of agriculture and farm wages are relatively high.

Worldwide, as countries' per capita incomes rise, their workforces shift out of agriculture, reflecting an amalgam of variables that raise the opportunity cost of farm work. In rural Mexico, education is expanding, the non-farm sector is growing, and birthrates are declining (Passel, Cohn, and Gonzalez-Barrera, 2012). We briefly describe how changes in rural Mexico and potential migration destinations might reduce incentives for individuals to allocate their labor to farm work in the course of what is commonly known as "the agricultural transformation"

Diane Charlton is a Ph.D. candidate and J. Edward Taylor is a professor, both in the Department of Agricultural and Resource Economics at the University of California, Davis. Portions of this research or data collection were funded by the William and Flora Hewlett Foundation, the Ford Foundation of Mexico, the University of California, Davis Temporary Migration Cluster, the Giannini Foundation of Agricultural Economics, University of California Institute on Mexico, UCMEXUS, the U.S. Department of Agriculture, Mexico's National Council on Science and Technology (Consejo Nacional de Ciencia y Tecnología, CONACYT), and the National Institute of Food and Agriculture (NIFA). We are indebted to Antonio Yúnez-Naude and the staff of Program for the Study of Economic Change and Sustainability of Mexican Agriculture (Programa de Estudio del Cambio Económico y la Sustentabilidad del Agro Mexicano, PRECESAM) and of Desarrollo y Agricultura Sustentable (DAS, Development and Sustainable Agriculture) for their invaluable assistance and data support.

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(Timmer 1988). We then perform econometric analysis of unique, nationally-representative longitudinal data on individual labor allocations from 1980 to 2010 to test whether the farm labor supply from rural Mexico is decreasing.

Our baseline dynamic model reveals a significant negative trend in the probability of individuals supplying labor to farm work, which is equivalent to an annual decline of over 150,000 farmworkers. The propensity to perform farm work varies across Mexico's five census regions; however, the trend is negative in all regions. We expand the model to decompose the negative trend into its key determinants. Decreasing rural family size, growth in non-farm employment, and the expansion of rural education accelerate the negative trend. U.S. farm wages and border enforcement effort mitigate it, though their effect is quantitatively small. Including these additional variables attenuates, but does not eliminate, the significant and negative time-trend effect.

An inward shift in the farm labor supply from rural Mexico impacts both the Mexican and U.S. farm industries, as farmers from both countries compete for a diminishing number of farmworkers. Simulations using a computable general equilibrium model indicate that a substantial reduction in the supply of unauthorized workers to the United States (which is the source of about half of the farm labor force) can be expected to cause a long run decline in agricultural and non-agricultural output and exports, an increase in real agricultural wages, and a decrease in aggregate levels of income and production, including rents to complementary factors of production (Zahniser et al. 2012). It also may create incentives for technological change not captured by existing models.

An ongoing farm labor policy discussion focuses on giving farmers easier access to foreign workers through streamlined guest-worker programs. However, our findings suggest that changes in immigration policy may have limited impacts on the farm labor supply. We find significant persistence in U.S. farm work, but declining family size, increasing schooling, and the aging of the workforce from rural Mexico all reduce the supply of workers to U.S. farms. Increasing U.S. farm wages clearly do the opposite; yet the impacts of U.S. farm wages on rural Mexicans' probability of working in U.S. agriculture are only significant in the short run. This is consistent with the observation that many immigrants to U.S. agriculture eventually move to other sectors (Martin 2002).

Mexico's diminishing farm labor supply exerts upward pressure on farm wages, creates incentives for the mechanization of labor-intensive tasks, potentially strengthens the bargaining position of workers and unions, and raises questions about whether U.S. immigration policy can offer a durable solution to the U.S. farm labor problem. It also likely contributes to a decline in farm labor migration *within* the United States (Fan et al. 2015). Reducing barriers to migration could raise the expected returns to working in agriculture, but once workers migrate they have the option of seeking work in the U.S. non-farm sector. How these competing forces interact to determine the farm labor supply from rural Mexico is theoretically ambiguous.

In addition to its relevance for agriculture in the United States and Mexico, this article offers new insights into how agricultural transformation unfolds in a less-developed country linked with labor markets in a more developed country. Other studies investigate the agricultural transformation, its causes, and consequences, including in the context of international migration (see, e.g., Taylor et al. 1996). This is the first article, to our knowledge, that identifies the trend in the farm labor supply and measures the impacts of both source and destination country variables on the trend.

Farm Labor and Agricultural Transformation

The received wisdom in development economics is that the domestic supply of agricultural labor starts out being relatively elastic; however, it shifts inward and becomes less elastic as countries' per-capita incomes increase and people shift out of the farm sector (Taylor, Charlton, and Yúnez-Naude 2012). Lewis's (1954) seminal study envisions an economy at low levels of development in which there is an abundant supply of labor. Thus, the marginal value product of labor (MVPL) in the farm sector is below the subsistence wage, and in the limiting case, approaches zero. In this model, investment in the non-farm economy induces workers to transition from the farm to the non-farm sector without putting upward pressure on wages. International migration was not part of the Lewis model, but by extension, the agricultural sector of a high-income neighboring country (e.g., the United States) with a porous border would face a similarly elastic labor supply from the source region. This would enable the foreign-country agricultural sector to expand its labor demand without exerting significant upward pressure on wages.

At the "Lewis turning point," the migrant-destination labor market succeeds in absorbing the rural labor surplus, the MVPL in agriculture exceeds the subsistence wage, and the destination economy must offer higher wages in order to attract new workers (Ranis and Fei 1961; Jorgenson 1961). The domestic non-farm sector competes with the farm sector for rural labor, and the foreign agricultural sector competes with both. The expansion of domestic non-farm employment, other things being equal, decreases the supply of labor to agriculture.

Taylor et al. (1996) found evidence that rural Mexico was past the Lewis turning point, inasmuch as the agricultural product on household farms decreased when household members migrated. The present study offers more compelling evidence since workers are shifting out of agriculture even as farm wages rise.

Two critical concomitants of growth and modernization, the fertility transition and the expansion of access to schooling, negatively affect the farm labor supply. Declining birthrates, a quintessential feature of economic development (Lee 2003), has a direct negative impact on the labor supply (with a lag). Access to schooling makes workers more productive, increases their wages, particularly in non-farm jobs, and as a consequence, stimulates their mobility out of farm jobs (Ashenfelter, Harmon, and Oosterbeek 1999; Massey et al. 1999; Taylor and Yúnez-Naude 2000). The Mexican government invested substantially in primary and secondary education during the period of this study. Public spending on education in Mexico rose from 2.9% of the GNP in 1980 to 5.1% in 2010 (The World Bank 2014). Federal programs to increase school attendance include the well-known conditional cash transfer program, Progresa/Oportunidades (subsequently renamed Prospera), which began in 1997. Under this program, poor households were eligible to receive cash transfers conditional upon children's school attendance and health check-ups. Studies show that the program significantly increased school attainment for children from poor households (Skoufias, Davis, and De La Vega 2001; Schultz 2004). Given the well-known asymmetries in returns to schooling across sectors (Taylor and Yúnez-Naude 2000), improvements in educational attainment are expected to accelerate rural Mexico's transition out of agriculture.

A plethora of dual-economy models theoretically analyze the pull factors (i.e., non-farm labor demand) and push factors (i.e., technological change in agriculture) shaping the movement of labor off the farm (Ranis and Fei 1961; Jorgenson 1961; Harris and Todaro 1970; Lele and Mellor 1981; Timmer 1988). In order to induce domestic workers to supply their labor to farm jobs, agricultural wages must rise apace with nonagricultural wages. This is all the more true if non-farm jobs bring non-pecuniary benefits compared to farm jobs and/or workers associate farm jobs with drudgery.

Rural Mexico is distinctive inasmuch as it supplies farm and non-farm labor to both Mexico and the United States. Because of this, the two countries' farm labor markets are linked, and changes in rural Mexico's farm labor supply reverberate across the border. In theory, U.S. farm wages, like non-farm wages in Mexico, may influence rural Mexico's farm labor supply. So might U.S. border enforcement, by restricting Mexicans' access to those wages. In the past, as U.S. workers transitioned out of hired farm work, U.S. agriculture avoided significant wage increases by tapping the farm labor supply of a country at an earlier stage in the farm labor transition. This has begun to change in recent years. USDA, National Agricultural Statistics Service (NASS; 2014) data show increases in farm wages generally and striking increases in some regions (see figure 1).

Theory

The classic mover-stayer model by Harris and Todaro (1970) shows that individuals move from the agricultural sector to the urban sector if the expected wage in the urban sector, net the cost of migration, is greater than the wage in the agricultural sector. Many factors, some observed and some unobserved, impact the expected costs and benefits of working in a given sector or location. Some costs and benefits are monetary, such as the physical costs of travel and wages paid, while others are related to individual preferences that cannot be observed.

We analyze the impacts of individual-, sector-, and location-specific characteristics on sector choice using a random utility model approach, as described by McFadden (1973), Mincer (1974), and Walker and Ben-Akiva (2002). This model has been used extensively in the economics literature on locational choice; examples include Emerson (1989), Robinson and Tomes (1982), Falaris (1987), Nakosteen and Zimmer (1980), Perloff, Lynch, and Gabbard (1998), and Taylor (1987). A key implication of this model is that changes in variables affecting the supply of labor to *any* sector or location have consequences for labor supply to *all* sectors and locations. For example, if schooling increases the relative economic returns from non-farm employment, as research from Mexico suggests (Yúnez-Naude and Taylor 2001; De Janvry and Sadoulet 2001), it will negatively affect the supply of labor to agriculture. Higher U.S. farm wages may increase the total farm labor supply while decreasing the supply of labor to farms in Mexico. Increased U.S. border enforcement could do the opposite if it dissuades rural Mexicans from migrating northward.

Observable characteristics likely to influence an individual's expected wages at a particular sector-location in a human capital model include education, experience (or age), and gender (Mincer 1974). An agricultural household model would add time-invariant as well as time-varying household characteristics, including household size, and location characteristics that affect the economic returns to labor in the village of origin. Returns to off-farm labor are shaped by wages, non-farm sector GDP, and barriers to mobility such as U.S. border enforcement and crime. The unobserved component of sector choice in this model includes skills and abilities, along with unobserved household characteristics and access to information and assistance networks of friends and family that provide job references, information, housing, and support.[1]

Business cycles in each country are likely to play a key role in the farm labor decision. The demand for labor-intensive fruits and vegetables is relatively inelastic, so the demand for farm labor is not expected to change substantially in response to a recession. However, Fan, Alves Pena, and Perloff (2015) contend that the supply of farmworkers in the United States may shift leftward during a recession because reduced demand for workers in other industries discourages migration from Mexico. These authors find evidence that total agricultural output remained steady throughout the 1991–92, 2001, and 2008–09 recessions, and undocumented migration decreased during the 2008 recession. Although migration is expected to decrease during a U.S. recession, reduced employment in non-farm industries, such as construction, is also expected to cause Mexican immigrants, formerly employed in the non-farm sector, to shift to the farm sector, either in the United States or in Mexico. Taylor, Charlton, and Yúnez-Naude (2012) find no evidence that this occurred, suggesting that workers from rural Mexico were shifting out of agriculture even in the face of unfavorable non-farm employment opportunities.

Since the question of interest is whether the labor force from rural Mexico is transitioning out of agriculture and how quickly, we first consider what factors determine whether individuals work in the agricultural or non-agricultural sector. Then we investigate the decision to work in the Mexican and U.S. farm sectors separately.

Data

We use individual panel data from a nationally representative sample of rural Mexicans to test for changes in the agricultural labor supply over time. The Mexico National Rural Household Survey (Spanish acronym ENHRUM) is unique in providing retrospective panel data on individuals' labor allocations over an extended time period (from 1980 to 2010).[2]

The map in figure 2 shows Mexico divided into its five census regions and the locations of the original ENHRUM surveys (denoted by red dots).[3]

The panel data come from three survey rounds: 2002, 2007, and 2010. Locations and

[1] Empirically, we can partially control for network effects by including village or household fixed effects in the regression.

[2] *Encuesta Nacional a Hogares Rurales de México.*

[3] The surveys in the northeast were dropped from the 2010 survey, so we do not have data for households in this region for 2008–2010. Some of the original localities shown on the map were randomly excluded from the final survey round, due to budget constraints or because a high incidence of violence made field work infeasible.

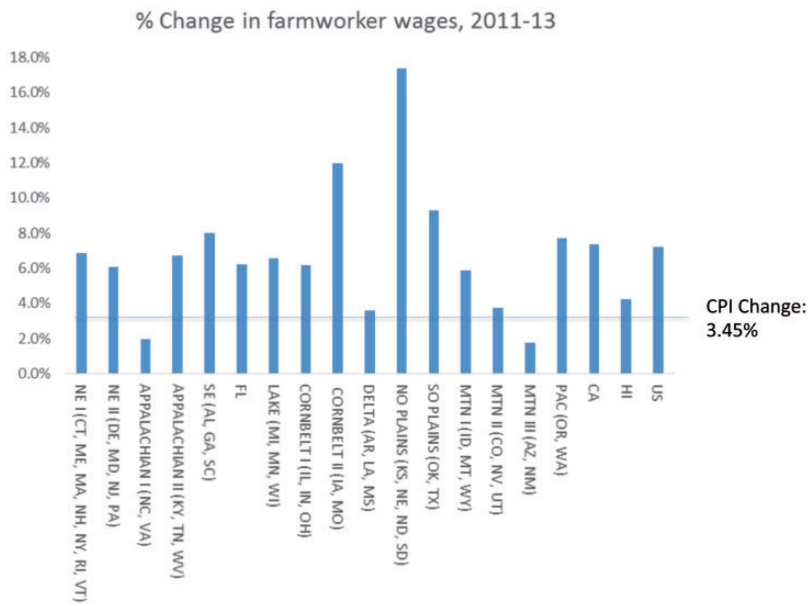

Figure 1. Changes in average farmworker wages between 2011 and 2013 by U.S. region

households were randomly selected with collaboration from the *Instituto Nacional de Estadística y Geografía* (National Institute of Statistics and Geography, INEGI) in Mexico so as to be nationally representative of rural Mexico in 2002. Each round gathered detailed information on individuals' sector of work (agricultural or non-agricultural), employment status (wage-earner or self-employed), and migration destinations (United States or Mexico). These data were gathered for all family members, including the household head, his/her spouse, all others living in the household, and children of the household head or spouse living outside the household at the time of the surveys. Work histories were assembled as far back as 1980 for a randomly selected group of family members residing outside the household and back to 1990 for all family 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 (other than because of violence) was random in order to maintain the national representativeness of the original sample.

Table 1 reports summary statistics on selected variables. Individuals in the analysis are limited to the 15–65 year age group, which is the expected working age interval in rural Mexico used in much of the labor literature. About 32% of the sample worked in agriculture between 1980 and 2010, while 33% worked in the non-agricultural sector. The mean age of the sample is 33 years. A little less than half of the sample are women.[4] Most households inherit little land. The average extension of inherited land is 1.87 hectares and the maximum is 507 hectares. In an average household, about half of the members are adults. Adults are working age (15 to 65) while children are under 15. The low child/adult ratio reflects slowing birth rates in rural Mexico. Children are added to the working-age sample once they turn 15.

Tables 2 and 3 break down the sector and location of work by year of birth and age. Table 2 shows the mean years that an individual worked in the agricultural and non-agricultural sectors as a share of the total years reported working. It also includes the mean years that an individual worked in the agricultural and non-agricultural sectors as a

[4] We suspect that some women did not report their work history (possibly because they did not work outside the home). Controlling for gender should rid the analysis of any bias that this might introduce.

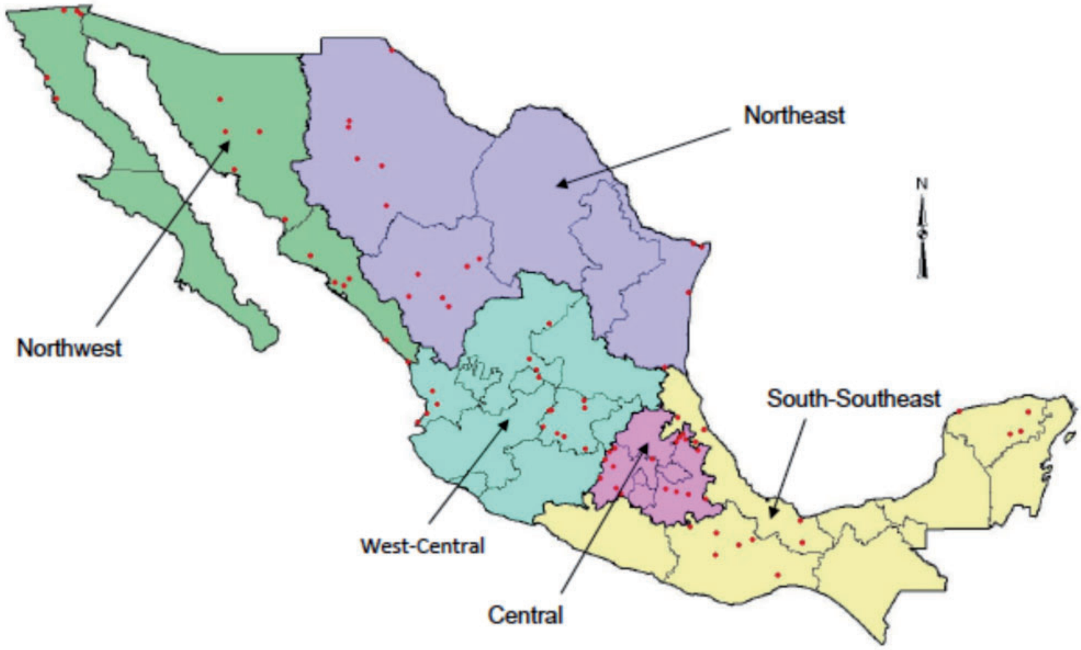

Figure 2. Map of ENHRUM villages

share of total years aged 15 or older and the mean number of consecutive years that an individual worked in the agricultural and non-agricultural sectors conditional on working in the respective sector at least once. Summary statistics are separated into four birth cohorts.[5]

Older generations generally work a larger share of their economically-active years in agriculture compared to younger generations. The expected number of consecutive years that an individual works in the agricultural or non-agricultural sector decreases for younger generations, which is not surprising since individuals from older generations have generally worked more years overall. The mean stretch of consecutive years worked in the agricultural sector is longer than the mean stretch of years worked in the non-agricultural sector only for individuals born in 1960 or earlier.

Table 3 shows that, on average, younger cohorts of rural Mexicans are less likely to work in agriculture. This observation holds for each year. The expected probability of working in agriculture in Mexico appears to be decreasing for all age groups between 1980 and 2010. The expected probability of working on U.S. farms is much lower than that of working on Mexican farms, and it appears to move in the opposite direction at the beginning of the period. The probability rises from 1980 through 2000 for all age groups, and then falls for all but the oldest age group between 2000 and 2010. In 1980, the probability of working on U.S. farms was highest for the 15–29 year age group, but in 2010 was lowest for this age group.

In addition to work outcomes, the survey records completed years of schooling. Years of education differ substantially across generations, with younger generations being more highly educated than older generations, on average. Table 4 shows years of education by age group in 2010. Individuals in their twenties have a mean education of 9 years while those in their fifties have a mean of only 5 years, reflecting a sharp rise in secondary schooling between 1970 and 2000.

We use the ENHRUM data to identify the trend in the farm labor supply from rural Mexico between 1980 and 2010, and then we unpack the trend into its component factors. Factors include changes in individual and household characteristics along with economy-wide trends. We supplement the ENHRUM data with national Mexican

[5] We repeated the summary analysis in table 2 for the shares of years worked in the agricultural and non-agricultural sectors in Mexico and the United States separately. The findings are similar to those in table 2.

Table 1. Summary Statistics

VARIABLES	Mean	SD	Min.	Max.
Agriculture	.324	.468	0	1
Non-Agriculture	.334	.472	0	1
Age	32.6	12.7	15	65
Female	.445	.497	0	1
Inherited Land (ha)	1.87	19.4	0	507
Child:Adult Ratio in HH	.492	.671	0	10

Note: Number of observations: 154,766 person-years.

Table 2. Mean Shares and Continuous Stretches of Years Worked in Each Sector (1980–2010)

	Born 1960 or earlier	Born 1961-1970	Born 1971-1980	Born 1981-1995
Share Ag. of Years Reported Working	.591 (.447)	.405 (.428)	.333 (.400)	.378 (.430)
Share Non-Ag. of Years Reported Working	.420 (.446)	.608 (.422)	.677 (.394)	.633 (.426)
Share Ag. of Years Age 15+	.392 (.431)	.273 (.369)	.217 (.322)	.201 (.319)
Share Non-Ag. of Years Age 15+	.241 (.349)	.360 (.372)	.385 (.350)	.285 (.332)
Mean Consecutive Years Ag. if Ever Worked Ag.	14.690 (10.516)	9.757 (9.006)	5.135 (4.038)	3.347 (2.255)
Mean Consecutive Years Non-Ag. if Ever Worked Non-Ag.	12.647 (10.667)	9.815 (8.706)	5.893 (4.196)	3.546 (2.345)
Share Reported Working of Years Age 15+	.625 (.412)	.624 (.387)	.595 (.364)	.479 (.385)
Ever Reported Working	.796 (.403)	.838 (.368)	.846 (.361)	.718 (.450)
Observations in Cohort	1,171	1,014	1,341	1,929

Standard deviations in parentheses.

non-farm employment and exchange rate data from The World Bank (2014), border patrol data from U.S. Department of Homeland Security (2014), U.S. farm wage data from U.S. Department of Labor, Employment and Training Administration (2014), and municipal-level indicators of violence in Mexico from INEGI (2015).

Empirical Model: Identifying the Time Trend

Our panel consists of the labor allocations of a random sample of 9,837 rural Mexicans from 1980 through 2010—a total of $N = 154{,}766$ person-years of information over $T = 31$ years. We use this panel to identify the trend in probability that rural Mexicans work in agriculture.[6] Given the length of the panel and the number of observations, asymptotically $T \rightarrow \infty$ and $N \rightarrow \infty$. We use the linear probability model because it is the best-performing estimator when T is large and the data are unbalanced (Judson and Owen 1999). We later test the robustness of this assumption using a logit model.

Let $Y_{i,t}$ be the outcome of interest, where $Y_{i,t}$ is equal to 100 (to show percentage-point impacts) if individual i works in the agricultural sector in year t, and zero otherwise. We regress $Y_{i,t}$ on its lag and a yearly time trend.

[6] A number of individuals enter or leave the working-age population over the time period of the panel; thus, person-years $< N * T$.

We include the lagged dependent variable to control for persistence in an individual's labor choice decision from one year to the next. This controls for some of the inflexibility that prevents workers from immediately switching sectors in response to market demands. We estimate the model with one, two, and three lags and find that the third lag is no longer significant. We thus use the model with two autoregressive terms:

$$(1) \quad Y_{i,t} = \beta_0 + \beta_1 t + \gamma_1 Y_{i,t-1} + \gamma_2 Y_{i,t-2} + \epsilon_{i,t}.$$

Including the autoregressive term purges the time trend of any autocorrelated unobserved variables that affect the probability of working in agriculture. Controlling for the lagged dependent variable, a linear time trend and error term remain. Since individual work decisions are likely correlated across years, $\epsilon_{i,t}$ is not independently and identically distributed. Let

$$(2) \quad \epsilon_{i,t} = \alpha_i + u_{i,t}.$$

Since α_i is correlated across years, it can be a source of concern in some economic models. However, Nickell (1981) demonstrates that including individual fixed effects leads to biased estimated coefficients in dynamic models. Since the objective of this analysis is to identify the time trend, which is not correlated with α_i by definition, OLS estimation will give consistent estimates of a linear trend. We estimate both a national time trend and region-specific time trends, inasmuch as the data are representative of rural populations in Mexico's five census regions.

Next we control for a vector of individual, household, and regional characteristics hypothesized to influence the probability of working in agriculture. Call this vector $\boldsymbol{X}_{i,t}$. These characteristics include regional fixed effects, age, gender, education, and household size. Lastly, we control for a vector of trending variables, $\boldsymbol{Z}_{i,t}$. These include the industrial and service employment in Mexico, intensity of U.S.-Mexico border enforcement, real U.S. farm wages, and the homicide rate in the home municipality. Regressing the outcome variable only on level values of trending variables would return short-run marginal impacts that are potentially cointegrated with the probability of working in agriculture. To find long-run impacts and control for short-term shocks, we regress on both lagged level effects, $\boldsymbol{Z}_{i,t-1}$, and differences, $\Delta \boldsymbol{Z}_{i,t} = \boldsymbol{Z}_{i,t} - \boldsymbol{Z}_{i,t-1}$:

$$(3) \quad Y_{i,t} = \beta_0 + \beta_1 t + \beta_2 \boldsymbol{X}_{i,t} + \delta_1 \boldsymbol{Z}_{i,t-1} + \delta_2 \Delta \boldsymbol{Z}_{i,t} + \gamma_1 Y_{i,t-1} + \gamma_2 Y_{i,t-2} + \epsilon_{i,t}.$$

The coefficient on the differenced term indicates the short-run effect on the dependent variable of a shock in the explanatory variable. After controlling for differences, the coefficient on $\boldsymbol{Z}_{i,t-1}$ indicates how quickly the dependent variable returns to equilibrium after a shock in the trending variable. To find the long-run impacts, we can rewrite equation (3) as

$$(4) \quad Y_{i,t} - \gamma_1 Y_{i,t-1} - \gamma_2 Y_{i,t-2} = \beta_0 + \beta_1 t + \beta_2 \boldsymbol{X}_{i,t} + \eta_1 \boldsymbol{Z}_{i,t} + \eta_2 \boldsymbol{Z}_{i,t-1} + \epsilon_{i,t},$$

where $\delta_1 = \eta_1 + \eta_2$ and $\eta_1 = \delta_2$. Then it is easy to see that the expected long-run effects are as follows:

residual trend (after controlling for other variables) $\frac{\beta_1}{1 - \gamma_1 - \gamma_2}$;

non-differenced variables $\frac{\beta_2}{1 - \gamma_1 - \gamma_2}$;

and trending variables $\frac{\eta_1 + \eta_2}{1 - \gamma_1 - \gamma_2} = \frac{\delta_1}{1 - \gamma_1 - \gamma_2}$.

Findings

In this section, we identify and unpack the trend in the farm labor supply from rural Mexico. We first consider the percentage probability of working in agriculture, making no distinction between agricultural work in Mexico or the United States, and then we look at the probability of working in agriculture in Mexico and the United States separately.

Time Trend

Table 5 reports the results from estimating national and region-specific trends using the baseline dynamic panel model. Lagged variables are indicated by the prefix L. The coefficient on the linear trend is significantly less

Table 3. Location and Sector of Work by Age in Four Selected Years

Age	Location-Sector	Mean	SD	Min.	Max.	Obs.
1980						
15–29	U.S. Agriculture	.012	.107	0	1	1,213
	MX Agriculture	.384	.487	0	1	1,213
30–39	U.S. Agriculture	.010	.010	0	1	500
	MX Agriculture	.500	.501	0	1	500
40–49	U.S. Agriculture	.006	.080	0	1	309
	MX Agriculture	.576	.495	0	1	309
50–65	U.S. Agriculture	.005	.069	0	1	208
	MX Agriculture	.611	.489	0	1	208
1990						
15–29	U.S. Agriculture	.016	.127	0	1	2,573
	MX Agriculture	.316	.465	0	1	2,573
30–39	U.S. Agriculture	.027	.161	0	1	972
	MX Agriculture	.355	.479	0	1	972
40–49	U.S. Agriculture	.020	.140	0	1	601
	MX Agriculture	.434	.496	0	1	601
50–65	U.S. Agriculture	.002	.047	0	1	449
	MX Agriculture	.530	.500	0	1	449
2000						
15–29	U.S. Agriculture	.024	.154	0	1	3,069
	MX Agriculture	.246	.431	0	1	3,069
30–39	U.S. Agriculture	.025	.156	0	1	1,567
	MX Agriculture	.266	.442	0	1	1,567
40–49	U.S. Agriculture	.032	.176	0	1	972
	MX Agriculture	.332	.471	0	1	972
50–65	U.S. Agriculture	.016	.124	0	1	833
	MX Agriculture	.438	.496	0	1	833
2010						
15–29	U.S. Agriculture	.010	.101	0	1	2,058
	MX Agriculture	.185	.388	0	1	2,058
30–39	U.S. Agriculture	.016	.124	0	1	1,341
	MX Agriculture	.181	.385	0	1	1,341
40–49	U.S. Agriculture	.017	.128	0	1	1,014
	MX Agriculture	.255	.436	0	1	1,014
50–65	U.S. Agriculture	.018	.131	0	1	802
	MX Agriculture	.298	.458	0	1	802

than zero at the national level and in every census region of Mexico. Column 1 of table 5 shows that the probability that an individual from rural Mexico works in agriculture decreases by 0.9 percentage points, on average, each year between 1982 and 2010, and the coefficient is significant at well below the 0.01 level.[7]

As a robustness check, column 2 of table 5 controls for age. Mean age is not constant throughout the panel. Many older individuals in the workforce in the 1980s passed away by 2003, when retrospective work histories were first recorded. Consequently, the mean age of the sample after 2003 is older than that of the sample before 2003. If the probability of working in agriculture is correlated with age, then the coefficient on the time trend may be biased. We find that the coefficient on age is significantly different from zero, and the coefficient on the trend is slightly larger (in absolute value) when age is in the regression. Scaling by the working-age population of rural Mexico in 2010 (16 million people), our findings indicate an expected decline in the farm labor supply of 155,360 persons per year.

Column 3 of table 5 allows for heterogeneity in the time trend across Mexico's five census regions. Agricultural work is more predominant in some regions of Mexico, particularly the south, and the transition out of

[7] The first two years of the panel are dropped from the regression because we include two autoregressive lags as explanatory variables.

Table 4. Years of Completed School by Age in 2010

Age	Years of Completed School				
	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

Table 5. Identifying the Trend in the Percentage Probability of Working in Agriculture (1982–2010)

	(1) Baseline National Trend		(2) Control for Age		(3) Regional Trends	
VARIABLES	Estimated Coefficients	Adjusted Long Run Impacts	Estimated Coefficients	Adjusted Long Run Impacts	Estimated Coefficients	Adjusted Long Run Impacts
t	−0.074	−0.900	−0.081	−0.971		
	(0.007)***	(0.081)***	(0.007)***	(0.080)***		
Age in Year t			0.042	0.507	0.044	0.520
			(0.004)***	(0.049)***	(0.004)***	(0.048)***
Central Region					0.500	5.843
					(0.430)	(5.023)
West-Central Region					−0.306	−3.579
					(0.416)	(4.858)
Northwest Region					−0.415	−4.845
					(0.430)	(5.018)
Northeast Region					−1.723	−20.134
					(0.457)***	(5.317)***
South-Southeast Regional Trend					−0.062	−0.726
					(0.014)***	(0.165)***
Central Regional Trend					−0.094	−1.095
					(0.015)***	(0.176)***
West-Central Regional Trend					−0.109	−1.287
					(0.013)***	(0.154)***
Northwest Regional Trend					−0.110	−1.287
					(0.015)***	(0.179)***
Northeast Regional Trend					−0.058	−0.676
					(0.018)***	(0.206)***
L.Percentage Pr(Ag)	0.811		0.811		0.809	
	(0.009)***		(0.009)***		(0.009)***	
L2.Percentage Pr(Ag)	0.107		0.106		0.105	
	(0.009)***		(0.009)***		(0.009)***	
Observations	134,997		134,997		134,997	
R-squared	0.834		0.834		0.834	

Note: Regressions are Linear Probability Models. The dependent variable is a dummy variable equal to 100 if the individual worked in agriculture in year t and 0 otherwise. Robust standard errors appear in parentheses, clustered at the individual level; ***p < 0.01, **p < 0.05, and *p < 0.1.

agriculture may occur at different rates throughout the country. The south-southeast is the default region for the intercept. Individuals from northeastern Mexico are significantly less likely to work in agriculture. Trends in the probability of working in agriculture are significantly less than zero in all regions. Figure 3 graphs the predicted trends by region, controlling for age. All trend lines are downward sloping, though the intercepts are higher and the slopes steeper in some regions than in others. There is a slight rise in the expected probability of working in agriculture in 2003, the year when the work histories from the second and third survey rounds merge, which may suggest that there is some recall bias in the reporting of work histories. We test this hypothesis using overlapping work history data when we perform robustness checks below, and we still find a negative trend of similar magnitude in the farm labor supply. These trends are consistent with findings from the National Agricultural Worker Survey (NAWS) data, which show a sharp increase in the share of U.S. farmworkers from southern Mexico (U.S. Department of Labor, Employment and Training Administration 2014).[8]

Unpacking the Trend

We expand the baseline model to identify factors accelerating or mitigating the negative trend. These factors fall into four broad categories: variables associated with the agricultural transformation (the ratio of children to adults in the household, years of completed schooling, and lagged and differenced Mexican non-farm employment in the industrial and service sectors); U.S. agricultural "pull" factors (lagged and differenced strengths of the U.S. dollar and U.S. farm wages); intervening policy variables (the lagged and differenced intensity of U.S.-Mexico border enforcement effort, measured by the number of border patrol agents); and local "push" factors (lagged and differenced homicides per million residents reported in the local municipality).[9] *Ex-ante*, the impact of local violence on farm work is theoretically ambiguous. On the one hand, a threat of violence in the surrounding region may discourage mobility and trap individuals in local labor markets. However, violence also can create an incentive for migration, which could be to farm or non-farm jobs in other parts of Mexico or the United States. Crime may also create non-farm economic opportunities in the informal market.

Each factor is plotted across time in figure 4. The regression results appear in table 6. The years of analysis are limited to 1991–2010 because annual Mexican homicide data are not available prior to 1990.[10] Differenced explanatory variables are indicated by the symbol "Δ". The model in column 1 includes no fixed effects, column 2 includes village fixed effects, and column 3 includes household fixed effects. Including fixed effects has little impact on the remaining coefficients.

The slope on the trend variables changes positively or negatively as we include explanatory variables correlated with time. Controlling for variables that push or pull labor out of agriculture causes the coefficient on the trend to rise towards zero, while controlling for variables that retain workers in agriculture causes the coefficient on the trend to sink further below zero.

The results show that a higher household ratio of children to adults is associated with a greater probability of working in agriculture. This implies that declining birth rates in rural Mexico contribute to the decrease in the farm labor force. However, the coefficient is insignificant once we control for household fixed effects (column 3).

Greater educational attainment is associated with a lower probability of working in agriculture. Since education may select on household and individual characteristics, causal impacts of schooling are difficult to identify with certainty in models of labor-market outcomes. However, irrespective of individuals' and households' educational preferences, national policy substantially expanded access to rural schools during the period covered by our data, as reflected in

[8] Analysis of the NAWS reveals that the percentage of U.S. hired farmworkers from southern Mexico rose from 2% in 1989 to 20% in 2012.

[9] A population census is available in Mexico only every 5 years; thus, we estimate the population of the municipalities each year using linear projections between census years.

[10] Mexican non-farm employment data are missing in years 1992 and 1994. As a robustness check, we unpacked the trend using the ratio of Mexico's industrial to agricultural GDP instead of non-farm employment. We found similar results for all explanatory variables, and Mexico's non-farm to farm GDP is also a significant factor pulling workers out of agriculture.

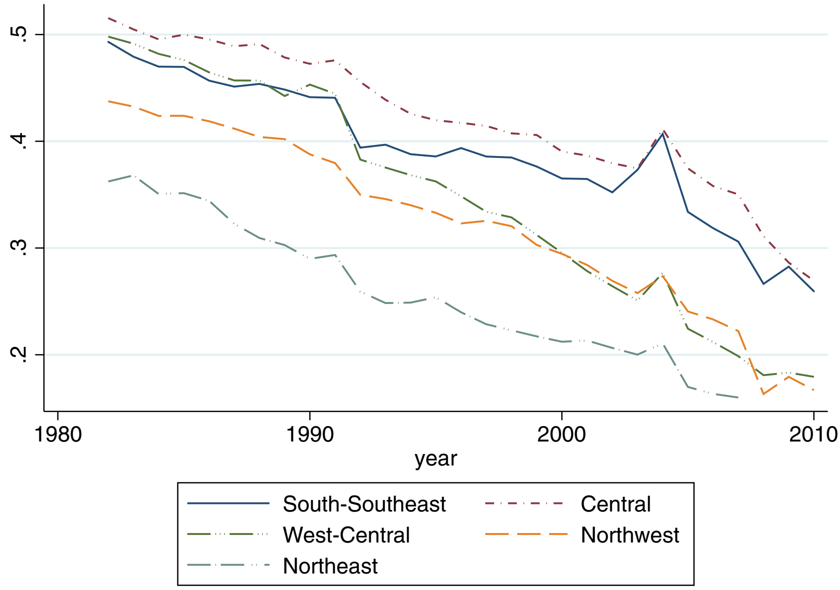

Figure 3. Predicted probability of working in agriculture by region

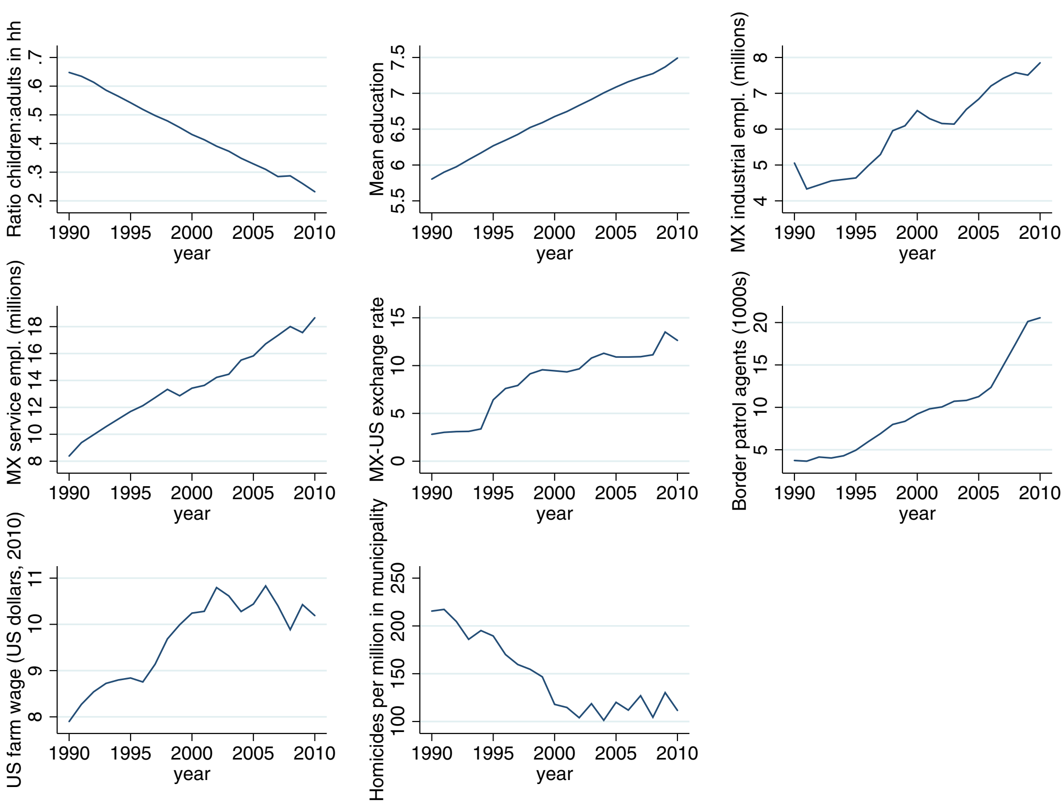

Figure 4. Mean factors expected to affect the farm labor supply

Table 6. Unpacking the Trend in the Percentage Probability of Working in Agriculture (1991–2010)

	(1) No FE		(2) Village FE		(3) Household FE	
VARIABLES	Estimated Coefficients	Adjusted Long Run Impacts	Estimated Coefficients	Adjusted Long Run Impacts	Estimated Coefficients	Adjusted Long Run Impacts
t	0.815	6.714	0.803	5.979	0.790	4.864
	(0.381)**	(3.138)**	(0.385)**	(2.866)**	(0.389)**	(2.391)**
Age in Year t	0.028	0.234	0.035	0.258	0.056	0.344
	(0.007)***	(0.057)***	(0.007)***	(0.052)***	(0.008)***	(0.051)***
Female	−2.868	−23.620	−3.275	−24.379	−4.071	−25.061
	(0.162)***	(1.210)***	(0.164)***	(1.090)***	(0.170)***	(0.912)***
Ratio Children: Adults in HH	1.085	8.937	1.052	7.831	0.378	2.327
	(0.148)***	(0.1208)***	(0.152)***	(1.118)***	(0.246)	(1.513)
Years of Education	−0.172	−1.417	−0.163	−1.216	−0.165	−1.017
	(0.019)***	(0.152)***	(0.020)***	(0.150)***	(0.027)***	(0.164)***
L. MX Industrial Employment	−0.003	−0.021	−0.002	−0.017	−0.002	−0.014
(1,000s)	(0.001)***	(0.006)***	(0.001)***	(0.005)***	(0.001)***	(0.004)***
Δ MX Industrial Employment	0.002		0.002		0.002	
(1,000s)	(0.001)**		(0.001)**		(0.001)**	
L. MX Service Employment	−0.001	−0.010	−0.001	−0.009	−0.001	−0.008
(1,000s)	(0.001)**	(0.005)**	(0.001)**	(0.005)**	(0.001)**	(0.004)**
Δ MX Service Employment	−0.002		−0.002		−0.002	
(1,000s)	(0.001)***		(0.001)***		(0.001)***	
L. MX-U.S. Exchange Rate	−1.637	−13.483	−1.615	−12.019	−1.534	−9.443
	(0.467)***	(3.852)***	(0.467)***	(3.482)***	(0.469)***	(2.891)***
Δ MX-U.S. Exchange Rate	−0.845		−0.781		−0.707	
	(0.340)**		(0.341)**		(0.340)**	
L. U.S. Farm Wage	1.948	16.039	1.978	14.724	1.875	11.542
	(0.614)***	(5.069)***	(0.614)***	(4.576)***	(0.608)***	(3.748)***
Δ U.S. Farm Wage	0.318		0.280		0.210	
	(0.438)		(0.440)		(0.439)	
L. Border Patrol Agents	0.716	5.895	0.692	5.154	0.627	3.860
(1,000s)	(0.148)***	(1.221)***	(0.149)***	(1.110)***	(0.147)***	(0.906)***
Δ Border Patrol Agents	0.101		0.094		0.061	
(1,000s)	(0.229)		(0.231)		(0.232)	
L. Homicides per Million	−0.001	−0.006	−0.000	−0.001	−0.000	−0.001
	(0.001)	(0.006)	(0.001)	(0.011)	(0.002)	(0.009)
Δ Homicides per Million	−0.002		−0.001		−0.001	
	(0.001)**		(0.001)		(0.001)	
L. Percentage Pr(Ag)	0.798		0.790		0.765	
	(0.008)***		(0.008)***		(0.008)***	
L2. Percentage Pr(Ag)	0.081		0.075		0.072	
	(0.008)***		(0.008)***		(0.008)***	
Observations	65,476		65,476		65,476	
R-squared	0.794		0.795		0.802	

Note: Regressions are Linear Probability Models. The dependent variable is a dummy variable equal to 100 if the individual worked in agriculture in year t and 0 otherwise. Mexican industrial and service employment data are missing in 1992 and 1994. Robust standard errors appear in parentheses, clustered at the individual level; ***p < 0.01,** p < 0.05, and *p < 0.1.

figure 4. Our findings suggest that public investment in rural education accelerated the transition of labor out of farm work, though school supply data are unavailable. Including household fixed effects does not change the result on schooling in any way, lending credence to the argument that schooling supply drives attainment in rural areas.

As expected, increased employment in Mexico's non-farm sector decreases the probability of working in agriculture, suggesting that the agricultural sector must compete

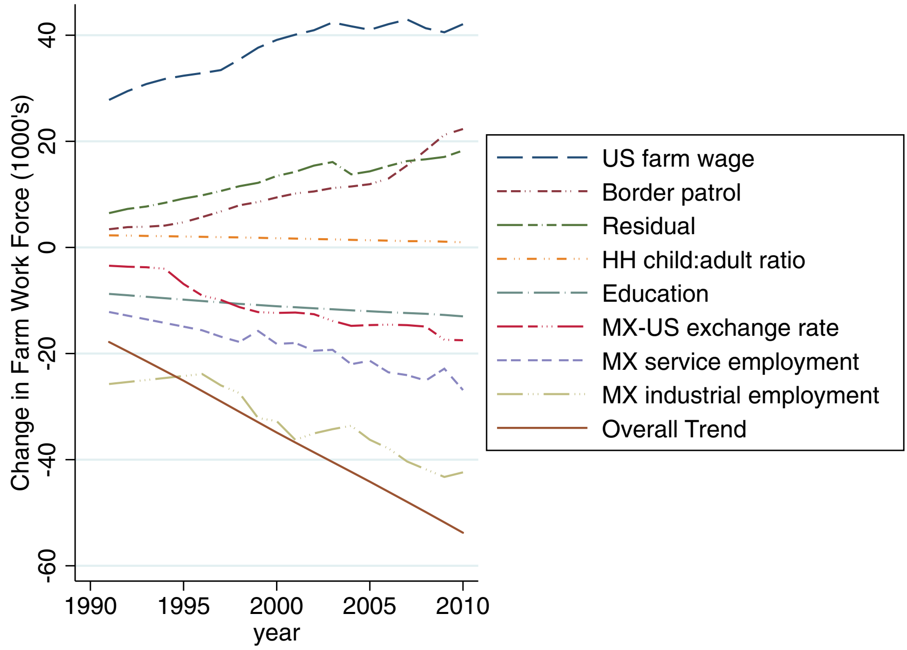

Figure 5. Unpacking the trend into its components, controlling for household fixed effects

with the non-agricultural sector for workers. An additional job in the industrial sector reduces the probability of working in the agricultural sector by more than an additional job in the service sector.

Economic conditions and immigration policies in the United States significantly impact rural Mexicans' labor sector decisions. When the Mexican peso is strong relative to the U.S. dollar, individuals are less likely to work in agriculture. This is not surprising to the extent that peso revaluation signals a robust non-farm economy. Rising U.S. agricultural wages draw some individuals into agricultural work, and increased border enforcement along the U.S.-Mexico border (proxied by the number of border patrol agents employed each year) appears to increase the probability of working in agriculture. This implies that workers at the margin who are discouraged from migrating when border enforcement rises, or those who are apprehended at the border, tend to work in Mexican agriculture in lieu of U.S. non-farm jobs. A different interpretation, that undocumented workers in the U.S. find jobs on U.S. farms as an alternative to returning to Mexico, is not supported by the country-specific farm labor supply regressions presented in the following section.

Table 6 shows no significant net impact of local violence (measured by homicides per million residents in the home municipality) on the probability of working in agriculture.

Figure 5 plots the share of the change in farm labor supply that each variable contributes to the trend after controlling for household fixed effects. We take the coefficients from table 6 column 3 and multiply them by the levels (and differences) of the corresponding variables. We then scale by the working age population in rural Mexico each year to find the change in farm labor supply from 1990 onward that can be explained by each variable of interest. The dashed or dotted lines in the figure represent the predicted change in farm labor supply attributable to each variable after controlling for household fixed effects. The solid line is the expected change in farm labor supply predicted from the baseline regression model in table 5, column 3; it is the sum of all of the dashed lines associated with each explanatory variable along with the influence of unobserved variables. The horizontal line at zero indicates no change in the farm labor supply from the previous year.

It is apparent that U.S. farm wages are a strong factor retaining workers in the farm sector, while the growth of Mexico's industrial sector is a strong factor pulling workers out of agriculture. The figure shows that there are also residual, unobserved variables that contribute towards a shift of workers out

Table 7. Identifying the Trend in the Percentage Probability of Working in Agriculture in Mexico (1982–2010)

	(1) Baseline National Trend		(2) Control for Age		(3) Regional Trends	
VARIABLES	Estimated Coefficients	Adjusted Long Run Impacts	Estimated Coefficients	Adjusted Long Run Impacts	Estimated Coefficients	Adjusted Long Run Impacts
t	−0.072 (0.007)***	−0.871 (0.080)***	−0.081 (0.007)***	−0.958 (0.079)***		
Age in Year t			0.051 (0.004)***	0.606 (0.0484)***	0.054 (0.004)***	0.616 (0.047)***
Central Region					0.391 (0.434)	4.484 (4.971)
West-Central Region					−1.035 (0.421)**	−11.867 (4.829)**
Northwest Region					−0.580 (0.434)	−6.654 (4.973)
Northeast Region					−1.687 (0.458)***	−19.345 (5.236)***
South-Southeast Regional Trend					−0.069 (0.014)***	−0.789 (0.163)***
Central Regional Trend					−0.095 (0.015)***	−1.093 (0.172)***
West-Central Regional Trend					−0.095 (0.013)***	−1.086 (0.152)***
Northwest Regional Trend					−0.108 (0.016)***	−1.242 (0.177)***
Northeast Regional Trend					−0.075 (0.017)***	−0.855 (0.199)***
L.Percentage Pr(MX Ag)	0.811 (0.009)***		0.810 (0.009)***		0.809 (0.009)***	
L2.Percentage Pr(MX Ag)	0.106 (0.009)***		0.105 (0.009)***		0.104 (0.009)***	
Observations	135,023		135,023		135,023	
R-squared	0.834		0.834		0.835	

Note: Regressions are Linear Probability Models. The dependent variable is a dummy variable equal to 100 if the individual worked in agriculture in year t and 0 otherwise. Robust standard errors appear in parentheses, clustered by individual; ***p < 0.01,**p < 0.05, and *p < 0.1.

of agriculture over time. We believe that a large part of the unobserved determinants is related to people's rising expectations with regard to economic livelihoods and working conditions, which tend to be at odds with a life of hired farm work. It is easy to imagine Mexico's increasing integration with the global economy and explosion of information through personal networks, the internet, and social media contributing towards shifting aspirations of young people growing up in rural areas. The impacts of factors accelerating the agricultural transition dominate those slowing it, resulting in a downward overall trend.

Mexican and U.S. Farm Labor Markets

Up to this point our analysis has combined the markets for farm labor in Mexico and the United States. There is reason to believe that these markets are highly integrated. Both primarily employ workers from rural Mexico and require similar levels of skill and effort. Many of the same crops are grown and traded in the two countries. However, immigration policy and migration costs and risks create barriers to entry into the United States; thus, labor markets are not *perfectly* integrated. Hanson (2006) reviews the literature regarding Mexico-U.S. migration. General findings show that illegal migration from Mexico to the United States increased between 1970 and 1990, but the composition of migrants also changed: more women, who are less likely to work in agriculture on average, began migrating to the United States; the selection of migrants is becoming more educated; and, in contrast with the itinerant farmworkers who extensively migrated to the United States in the 1950s and 1960s, more recent migrants tend to settle in the United States for the medium- to long-term. U.S. census data further show that between 1990 and 2000, the probability that migrants work in agriculture within the first 5 years of arriving in the United States fell by 8 percentage points for both men and women (Card and Lewis 2005).

We control for some barriers to entry by including border enforcement effort in our regression, but this does not account for all of the frictions that differentiate markets on the two sides of the border. For example, we do not observe migration networks, access to capital or credit to finance migration, or preferences for living near family or in one's home country.

Trend in Supply of Rural Mexican Workers to Mexican Farms

Table 7 reports findings from the Mexico-side model. The results indicate that the probability of rural Mexicans working in Mexico's farm sector declined by 0.96 percentage points each year, on average, between 1982 and 2010, after controlling for age. The trend is significantly less than zero in all of Mexico's census regions.

Table 8 unpacks the trend in the supply of labor to Mexican farms. The results are similar to those for the combined farm labor supply presented in table 6. U.S. farm wages tend to retain workers in the Mexican farm sector in the long-run (though we do not find a significant impact of short-run shocks from the differenced term), likely because they are correlated with Mexican farm wages, as theory suggests (Robertson 2000). Mexican farm wage data are not available for a sufficient number of years to test this hypothesis. Working on U.S. farms has no impact on the probability of working in Mexican agriculture in subsequent periods. In contrast, there is some evidence (table 10) that farm work in Mexico increases the likelihood of future farm work in the United States, suggesting that Mexican agriculture could be a temporary work choice for potential U.S. farm labor migrants.

Trend in the Supply of Rural Mexican Workers to U.S. Farms

Table 9 presents findings for U.S. agricultural work. Nationally, the trend in labor supply to U.S. agriculture is not significantly different from zero. Trends across regions of Mexico vary, however. The probability of working in U.S. agriculture from the south-southeast region increased between 1982 and 2010, while the trend from the west-central region was significantly less than zero.

The results in table 10 reveal several differences between the U.S. and Mexican farm labor markets. We do not find a significant impact of Mexican non-farm employment on the probability of working in U.S. agriculture, which suggests that the U.S. farm sector does not compete with the Mexican non-farm economy for workers. However, schooling significantly reduces the probability of working in U.S. agriculture. U.S. farm wages significantly increase the probability of working in agriculture in the short-run, as indicated by the coefficients on the differenced terms, but they do not have a significant long-run impact.

Robustness Checks

We performed several robustness checks to test the validity of the results. First, we found evidence that the results are robust to different functional forms by repeating the analysis using a nonlinear probability model. Second, we limited the sample to a single observation for each individual at a selected age, and we found negative trends of similar magnitudes, statistically significant at the 1% level. Third, we found evidence that, if anything, the results are attenuated by the attrition of households that moved out of the survey communities. Finally, the results are robust to various controls for the consistency of the household's recall of whether individuals worked in agriculture, using overlapping work histories from different survey rounds. The results from the nonlinear probability model are recorded below, and the results from the other robustness checks can be found in the supplemental appendix online.

Functional Form

All of the previous regressions employ a linear probability model, which is considered more efficient when T and N are large. However, since the dependent variable measures a probability, we can check whether the results differ when we use a nonlinear probability model. Table 11 shows the results from

Table 8. Unpacking the Trend in the Percentage Probability of Working in Agriculture in Mexico (1991–2010)

	(1) No FE		(2) Village FE		(3) Household FE	
VARIABLES	Estimated Coefficients	Adjusted Long Run Impacts	Estimated Coefficients	Adjusted Long Run Impacts	Estimated Coefficients	Adjusted Long Run Impacts
t	0.597	4.938	0.576	4.310	0.551	3.404
	(0.371)	(3.065)	(0.375)	(2.805)	(0.378)	(2.336)
Age in Year t	0.039	0.324	0.046	0.347	0.073	0.452
	(0.007)***	(0.056)***	(0.007)***	(0.052)***	(0.008)***	(0.051)***
Female	−2.459	−20.324	−2.811	−21.044	−3.535	−21.856
	(0.157)***	(1.212)***	(0.159)***	(1.095)***	(0.165)***	(0.914)
Ratio Children:Adults in HH	1.255	10.374	1.181	8.844	0.355	2.197
	(0.149)***	(1.213)***	(0.152)***	(1.123)***	(0.244)	(1.508)
Years of Education	−0.151	−1.250	−0.140	−1.051	−0.131	−0.808
	(0.019)***	(0.150)***	(0.020)***	(0.149)***	(0.026)***	(0.163)***
L. MX Industrial Employment	−0.002	−0.017	−0.002	−0.014	−0.002	−0.011
	(0.001)***	(0.006)***	(0.001)***	(0.005)***	(0.001)***	(0.004)***
Δ MX Industrial Employment	0.001		0.001		0.001	
	(0.001)		(0.001)		(0.001)	
L. MX Service Employment	−0.001	−0.008	−0.001	−0.007	−0.001	−0.006
	(0.001)	(0.005)	(0.001)	(0.005)	(0.001)	(0.004)
Δ MX Service Employment	−0.002		−0.002		−0.002	
	(0.001)**		(0.001)**		(0.001)**	
L. MX-U.S. Exchange Rate	−1.385	−11.450	−1.389	−10.400	−1.321	−8.165
	(0.448)***	(3.710)***	(0.449)***	(3.364)***	(0.450)***	(2.787)***
Δ MX-U.S. Exchange Rate	−0.615		−0.564		−0.516	
	(0.325)*		(0.326)*		(0.326)	
L. Border Patrol Agents	0.659	5.445	0.649	4.855	0.599	3.702
	(0.143)***	(1.181)***	(0.144)***	(1.076)***	(0.142)***	(0.877)***
Δ Border Patrol Agents	0.091		0.081		0.062	
	(0.222)		(0.224)		(0.225)	
L. U.S. Farm Wage	1.433	11.849	1.437	10.759	1.356	8.386
	(0.591)**	(4.893)**	(0.591)**	(4.425)**	(0.585)**	(3.619)**
Δ U.S. Farm Wage	−0.048		−0.091		−0.122	
	(0.424)		(0.425)		(0.425)	
L. Homicides per Million	−0.001	−0.005	−0.000	−0.001	−0.000	−0.000
	(0.001)	(0.006)	(0.001)	(0.011)	(0.001)	(0.009)
Δ Homicides per Million	−0.001		−0.001		−0.001	
	(0.001)		(0.001)		(0.001)	
L. Percentage Pr(US Ag)	0.004	0.033	0.004	0.032	0.007	0.043
	(0.006)	(0.050)	(0.006)	(0.047)	(0.007)	(0.043)
L. Percentage Pr(MX Ag)	0.795		0.788		0.763	
	(0.008)***		(0.008)***		(0.008)***	
L2. Percentage Pr(MX Ag)	0.084		0.078		0.076	
	(0.008)***		(0.008)***		(0.008)***	
Observations	65,488		65,488		65,488	
R-squared	0.793		0.794		0.801	

Note: Regressions are Linear Probability Models. The dependent variable is a dummy variable equal to 100 if the individual worked in agriculture in year t and 0 otherwise. Mexican industrial and service employment data are missing in 1992 and 1994. Robust standard errors appear in parentheses, clustered by individual; ***p < 0.01, **p < 0.05, and *p < 0.1.

running a logit model.[11] The table records the maximum likelihood marginal effects at the mean, scaled to percentage impacts. The even columns calculate the long-run impacts from the marginal effects as in the previous tables. The findings from the logit model are statistically significant and of a magnitude

[11] A probit is not an option when the model includes fixed effects (Cameron and Trivedi 2005)

Table 9. Identifying the Trend in the Percentage Probability of Working in Agriculture in the United States (1982–2010)

	(1) Baseline National Trend		(2) Control for Age		(3) Regional Trends	
VARIABLES	Estimated Coefficients	Adjusted Long Run Impacts	Estimated Coefficients	Adjusted Long Run Impacts	Estimated Coefficients	Adjusted Long Run Impacts
t	−0.001	−0.010	0.000	0.001		
	(0.003)	(0.019)	(0.003)	(0.19)		
Age in Year t			−0.009	−0.071	−0.009	−0.069
			(0.001)***	(0.011)***	(0.001)***	(0.011)***
Central Region					0.085	0.628
					(0.088)	(0.653)
West-Central Region					1.059	7.857
					(0.191)***	(1.547)***
Northwest Region					0.230	1.705
					(0.108)**	(0.812)**
Northeast Region					0.090	0.670
					(0.160)	(1.188)
South-Southeast					0.007	0.054
Regional Trend					(0.003)**	(0.022)**
Central Regional Trend					0.005	0.039
					(0.004)	(0.027)
West-Central Regional Trend					−0.020	−0.148
					(0.008)**	(0.063)**
Northwest Regional Trend					−0.004	−0.026
					(0.004)	(0.033)
Northeast Regional Trend					0.015	0.109
					(0.008)*	(0.062)*
L.Percentage Pr(US Ag)	0.775		0.775		0.774	
	(0.016)***		(0.016)***		(0.016)***	
L2.Percentage Pr(US Ag)	0.092		0.092		0.091	
	(0.016)***		(0.016)***		(0.016)***	
Observations	135,023		135,023		135,023	
R-squared	0.703		0.703		0.703	

Note: Regressions are Linear Probability Models. The dependent variable is a dummy variable equal to 100 if the individual worked in agriculture in year t and 0 otherwise. Robust standard errors appear in parentheses, clustered at the individual level; ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

similar to those from the linear probability model.

Conclusion

Mexicans are transitioning out of agriculture, just as the U.S. workforce did in the mid-twentieth century, and as workforces in all countries do as their economies grow. Rural Mexicans' probability of working in agriculture—whether in Mexico or the United States—declined by 0.97 percentage points annually between 1982 and 2010. Scaling this coefficient to the working age population in rural Mexico (16 million in 2010), this implies a decrease of over 150,000 workers in the farm labor supply each year. Mexico and the United States compete for this diminishing supply of farmworkers.

Many factors accelerate or decelerate the transition of rural Mexicans out of agriculture. Rural family sizes are decreasing and educational attainment in rural areas is rising, as the Mexican government invests in basic education for rural children. It is reasonable to conclude that a substantial part of the observed increase in educational attainment over time is explained by schooling supply, that is, improved access to K–12 schools in rural communities. A large, significant negative coefficient on schooling, even controlling for household fixed effects, provides reasonable evidence that access to education is partly responsible for the transition of labor out of agriculture.

Table 10. Unpacking the Trend in the Percentage Probability of Working in Agriculture in the United States (1991–2010)

	(1) No FE		(2) Village FE		(3) Household FE	
VARIABLES	Estimated Coefficients	Adjusted Long Run Impacts	Estimated Coefficients	Adjusted Long Run Impacts	Estimated Coefficients	Adjusted Long Run Impacts
t	0.058	0.380	0.066	0.403	0.090	0.460
	(0.173)	(1.130)	(0.177)	(1.084)	(0.179)	(0.909)
Age in Year t	−0.011	−0.073	−0.012	−0.075	−0.019	−0.097
	(0.003)***	(0.018)***	(0.003)***	(0.017)***	(0.003)***	(0.016)***
Female	−0.517	−3.375	−0.561	−3.441	−0.661	−3.365
	(0.055)***	(0.372)***	(0.059)***	(0.364)***	(0.062)***	(0.326)***
Ratio Children:Adults in HH	−0.220	−1.435	−0.144	−0.886	0.044	0.222
	(0.057)***	(0.376)***	(0.056)**	(0.348)**	(0.097)	(0.492)
Years of Education	−0.017	−0.108	−0.019	−0.114	−0.036	−0.181
	(0.007)**	(0.046)**	(0.008)**	(0.050)**	(0.010)***	(0.054)***
L. MX Industrial Employment	−0.000	−0.003	−0.000	−0.003	−0.000	−0.002
	(0.000)	(0.002)	(0.000)	(0.002)	(0.000)	(0.001)
Δ MX Industrial Employment	0.000		0.000		0.000	
	(0.000)		(0.000)		(0.000)	
L. MX Service Employment	−0.000	−0.001	−0.000	−0.001	−0.000	−0.001
	(0.000)	(0.002)	(0.000)	(0.002)	(0.000)	(0.001)
Δ MX Service Employment	−0.000		−0.000		−0.000	
	(0.000)		(0.000)		(0.000)	
L. MX-U.S. Exchange Rate	0.042	0.276	0.078	0.476	0.086	0.438
	(0.192)	(1.250)	(0.193)	(1.182)	(0.194)	(0.987)
Δ MX-U.S. Exchange Rate	−0.106		−0.090		−0.066	
	(0.137)		(0.138)		(0.138)	
L. Border Patrol Agents	0.024	0.158	0.009	0.057	−0.009	−0.048
	(0.053)	(0.349)	(0.054)	(0.331)	(0.053)	(0.270)
Δ Border Patrol Agents	0.093		0.094		0.081	
	(0.103)		(0.105)		(0.105)	
L. U.S. Farm Wage	0.400	2.613	0.409	2.513	0.389	1.980
	(0.243)*	(1.598)	(0.247)*	(1.524)*	(0.244)	(1.248)
Δ U.S. Farm Wage	0.446		0.451		0.411	
	(0.169)***		(0.171)***		(0.171)**	
L. Homicides per Million	−0.000	−0.001	−0.000	−0.001	−0.000	−0.001
	(0.000)	(0.002)	(0.001)	(0.004)	(0.001)	(0.003)
Δ Homicides per Million	−0.001		−0.000		−0.000	
	(0.000)		(0.000)		(0.000)	
L. Percentage Pr(MX Ag)	0.002	0.011	0.001	0.009	0.001	0.005
	(0.001)**	(0.005)**	(0.001)	(0.006)	(0.001)	(0.005)
L. Percentage Pr(U.S. Ag)	0.751		0.746		0.723	
	(0.021)***		(0.021)***		(0.021)***	
L2. Percentage Pr(U.S. Ag)	0.096		0.091		0.081	
	(0.020)***		(0.020)***		(0.020)***	
Observations	65,488		65,488		65,488	
R-squared	0.697		0.698		0.706	

Note: Regressions are Linear Probability Models. The dependent variable is a dummy variable equal to 100 if the individual worked in agriculture in year t and 0 otherwise. Mexican industrial and service employment data are missing in 1992 and 1994. Robust standard errors appear in parentheses, clustered at the individual level; ***p < 0.01, **p < 0.05, and *p < 0.1.

The impact of non-farm employment growth in Mexico is also a significant factor that is pulling workers out of agriculture. Industrial growth in Mexico is expected to continue shifting the demand for non-farm-workers outward, leading to higher non-farm wages. Rural youth, endowed with increasing levels of education, move to the non-farm sector, in which the returns to schooling are higher than in agriculture.

Tighter restrictions on border enforcement are associated with a greater probability of

Table 11. Percentage Probability of Working in Agriculture, Logit Model (1982–2010)

	(1) Baseline National Trend		(2) Control for Age		(3) Regional Trends	
VARIABLES	Marginal Effects	Adjusted Long Run Impacts	Marginal Effects	Adjusted Long Run Impacts	Marginal Effects	Adjusted Long Run Impacts
t	−0.064	−0.084	−0.071	−0.093	7.506	0.990
	(0.006)***	(0.007)***	(0.006)***	(0.007)***	(0.357)**	(0.471)**
Age in Year t			0.038	0.050	0.018	0.024
			(0.005)***	(0.006)***	(0.007)***	(0.009)***
Female					−2.995	−3.949
					(0.134)***	(0.179)***
Ratio Children:Adults in HH					0.993	1.310
					(0.139)***	(0.184)***
Years of Education					−0.198	−0.261
					(0.021)***	(0.028)***
L. MX Industrial Employment (1000s)					−0.002	−0.003
					(0.000)***	(0.001)***
Δ MX Industrial Employment (1000s)					0.001	
					(0.000)	
L. MX Service Employment (1000s)					−0.001	−0.002
					(0.000)**	(0.001)**
Δ MX Service Employment (1000s)					−0.002	
					(0.000)**	
L. MX-U.S. Exchange Rate					−1.066	−1.406
					(0.371)***	(0.490)***
Δ MX-U.S. Exchange Rate					−0.280	
					(0.301)	
L. U.S. Farm Wage					1.365	1.799
					(0.629)**	(0.830)**
Δ U.S. Farm Wage					−0.064	
					(0.418)	
L. Border Patrol Agents (1000s)					0.602	0.794
					(0.146)***	(0.193)***
Δ Border Patrol Agents (1000s)					0.010	−0.001
					(0.241)	(0.001)
L. Homicides per Million					−0.000	
					(0.000)	
Δ Homicides per Million					−0.002	
					(0.000)*	
L. Percentage Pr(U.S. Ag)	0.187		0.186		0.120	
	(0.002)***		(0.002)***		(0.002)***	
L2. Percentage Pr(U.S. Ag)	0.005		0.005		0.004	
	(0.002)***		(0.002)***		(0.002)***	
Observations	134,997		134,997		65,476	
Pseudo R-squared	0.751		0.752		0.715	

Note: The dependent variable is a dummy variable equal to 100 if the individual worked in agriculture in year t and 0 otherwise. Robust bootstrapped standard errors appear in parentheses; ***p < 0.01, **p < 0.05, and *p < 0.1.

working in the farm sector in Mexico but have no significant effect on the probability of working on U.S. farms. This suggests that workers deterred from migrating when the cost of migration rises are disproportionately likely to work in the farm sector in Mexico, whereas most rural Mexico-to-U.S. migrants perform non-farm work while in the United States. Conversely, a more accommodative immigration policy is expected to *decrease* the overall farm labor supply, while increasing U.S. farmers' access to it.

Increasing U.S. farm wages lead to the retention of some Mexican workers in agriculture, but to date the impact of these wages has not been strong enough to reverse the downward trend in overall farm labor supply from rural Mexico when we aggregate the workforce of those working either in Mexico or the U.S. Separate analyses for farm work in Mexico and the United States confirm that the farm labor supply is decreasing in Mexico. The absence of a significant trend in our analysis of rural Mexican labor supply to U.S. farms, combined with a positive impact of U.S. farm wages on the probability of working in U.S. agriculture, suggests that rising farm wages are a stabilizing influence in the United States.

Our econometric findings confirm anecdotal evidence of U.S. farm labor shortages at prevailing farm wages, as well as USDA-NASS data on rising real farmworker wages in nearly all U.S. regions. In the context of our interlinked Mexico-U.S. farm labor market model, it is not surprising to also see evidence of incipient farm labor organizing activity and wage increases in Mexico, including an unprecedented government guarantee of farmworker wages (Marosi 2015). In 2014, Mexico signed an agreement to permit temporary workers from Guatemala to work in Mexico (Secretary of Labor and Social Welfare, Secretaría del Trabajo y Previsión Social, Estados Unidos Mexicanos 2014).

In theory, U.S. farmers could respond to the diminishing supply of labor from rural Mexico by seeking new labor sources. Central American migration to U.S. farms rose from 2% of all crop workers in federal fiscal years 1999–2000 to 6% in 2011–2012 (U.S. Department of Labor, Employment and Training Administration 2014). With a total farm workforce only one-fourth the size of Mexico's and a declining farm employment share of its own, however, Guatemala is unlikely to have more than a marginal effect on the U.S. farm labor supply. Moving further south, Honduras and El Salvador have small work forces compared to Guatemala, and the shares of agriculture in total employment are falling faster there than in Guatemala.[12]

As the Mexican workforce shifts out of agriculture, immigration policy ceases to be a durable solution to the U.S. farm labor problem. In the short run, measures might be envisioned that enhance U.S. farmers' access to the diminishing supply of Mexican farm labor; a streamlined H-2A program is one example. However, in an era of diminishing farm labor supply, agricultural producers ultimately face little choice but to shift to less labor-intensive crops, technologies, and management practices. Our findings from Mexico have obvious relevance to other high-income countries that rely on an imported farm workforce. The findings also offer insights into the mechanisms driving the transition of labor out of agriculture in the course of economic development.

[12] Analysis of World Bank data, employment in agriculture (percentage of total employment; The World Bank 2014). Aggregate agricultural employment shares decreased at an average annual rate of 1.2% in El Salvador (1992–2012), 0.5% in Honduras (1998–2012), 0.2% in Guatemala (1992–2011), and 1.7% in Mexico (1993–2011). Year ranges reflect data availability.

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