Certified to migrate: Property rights and migration in rural Mexico

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Abstract

Improving security of tenure over agricultural land has recently been the focus of a number of large land certification programs. While the main justification for these efforts was to increase productive investments and facilitate land rental transactions, we show that if access rights were tied to actual land use in the previous regime, these programs can also lead to increased outmigration from agrarian communities. We analyze the Mexican ejido land certification program which, from 1993 to 2006, awarded ownership certificates to 3.6 million farmers on about half the country's agricultural land. Using the program rollout over time and space as an identification strategy, we show that households that obtained land certificates were 28% more likely to have a migrant member. The effect was larger for households with ex-ante weaker property rights and with larger off-farm opportunities. At the community level, certificates led to a 5% reduction in population, and the effects were larger in lower land quality environments. We show evidence of certificates leading to sorting, with larger farmers staying and land-poor farmers leaving in high productivity areas. We use satellite imagery to determine that, on average, cultivated land was not reduced because of the program, consistent with increases in agricultural labor productivity. Furthermore, in high productivity areas, the certification program led to an increase in cultivated land compared to low productivity ones. We confirm the validity of the results with checks on exogeneity of the rollout process relative to migration trends and on attrition in the panel dataset we use.

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1 Introduction

Complete property rights over land include the cumulative rights of access, extraction, management, exclusion of others, and alienation, where the last is the right to sell or transfer in perpetuity (Ostrom, 2001). Incomplete property right where jurisdiction over the exclusion of others is missing or uncertain implies insecurity of continued access to land and fear of expropriation. Typical of this situation are squatter and usufruct rights that are contingent on presence of the user and on active use to demonstrate property right and to defend the asset against seizure by others. Overcoming this situation requires land certification that assigns unconditional and unique access, extraction, management, and exclusion rights to beneficiaries, that can be individual or communal. Numerous studies have thus shown that improving land tenure security leads to increased investment and production (Besley, 1995; Jacoby, Li, and Rozelle, 2002; Do and Iyer, 2008; Field, 2005; Goldstein and Udry, 2008; Alston, Libecap, and Schneider, 1996; Deininger and Jin, 2006), more possibilities of renting to others and selling locally (Macours, de Janvry, and Sadoulet, 2010), and on- and off-farm labor reallocation (Do and Iyer, 2008). Incomplete property right where it is the right to alienate and transfer that is missing limits the possibility of sale to any willing buyer as well as of use as collateral to secure bank loans. Overcoming this situation requires full titling of beneficiaries, that can be individual or corporate. Studies have shown that property rights backed by a land title, a land registry, and courts that can uphold claims can lead to land being used as collateral to obtain loans (Chalamwong and Feder, 1988; De Soto, 2000) and the development of an active land market (Ravallion and Van de Walle, 2003).

In the developing world, the main source of inefficiency in agricultural land use that originates in incomplete property rights is due to lack of the right to exclude, creating insecurity of continued access (Besley and Ghatak, 2010). This can have large scale implications as it concerned half of Mexico before the 1992 constitutional reform, all of China where land could be reallocated by village authorities, and most of Sub-Saharan Africa where the community maintains jurisdiction over land reallocation.

The need to improve property rights by granting the right to exclude, and reciprocally the guarantee not to be expropriated by others, has led many countries to engage in certification programs. Certificates formally recognize land boundaries, and grant exclusive right of continued

access to beneficiaries even if the land if left idle or rented to others. Most notable were certification programs in Mexico, Ethiopia, and China (Deininger and Jin, 2006; Deininger, Jin, and Rozelle, 2006). While short of full titling, certificate programs can induce huge efficiency gains through security of investments, land rentals, and freeing labor from constrained on- and off-farm allocation, including the ability to migrate. In Vietnam, the certification program issued certificates that could be traded as full titles (Deininger and Jin, 2008). In general, the role of full titling in providing collateral for bank loans has been disappointing. This has been due to either lack of a credit market or lack of an insurance market to help protect the collateral from exposure to weather and other shocks (Boucher, Carter, and Guirkinger, 2008). The role of improved property rights in freeing labor also applies to residential urban land. Field (2007) thus found that titling of urban squatters in Lima allowed them to decrease presence of defensive labor in the house and to participate more freely to the labor market. This is however not universal. Galiani and Schargrodsky (2010) find no impact of land certification on labor supply among urban squatters in Buenos Aires, suggesting that a critical determinant of a labor response to titling is how constrained the squatter was before acquiring property right.

Mexico's land certification program (Programa de Certificacin de Derechos Ejidales y Titulacin de Solares, or Procede) provides an unusual natural experiment that allows to identify the impact of improved security of property rights on migration and land use. This is what we analyze in this paper. Results show that in property right environments where the right to exclude was incomplete, there may be inefficiently large amounts of labor allocated to agriculture because in doing so they also secure the right to the land, and that when property rights are secured, individuals and households can respond by increasing outmigration in considerable amounts. At the same time, there is heterogeneity of response, where those with better access to land may increase engagement in agriculture while those with less favorable access increase migration. The classical argument in favor of property rights improvement suggesting an overall increase in labor allocated to agriculture given that investments in land induced by land tenure security raise the marginal productivity of labor may thus not always hold.

Mexico's Procede program was rolled out nationwide over the 1993-2006 period to issue certificates of ownership over ejido land. Ejidos are agrarian communities that were created by the 1914 land reform where members (ejidatarios) were granted usufruct rights over individual plots

and common use lands.[1] However, because of lack of a formal title, rights were insecure from an individual point of view. For example, any land that was left fallow for more than two years could be reassigned to another family, or plots of land could be reassigned under simple majority agreement of other members of the community, leaving the individual with no further recourse. Procede gave ejidatarios land certificates declaring the name of the owner of each agricultural plot alongside a GIS map of the plot, and similarly for residential plots. Additionally, a certificate was issued to each ejidatario giving ownership of a share of common use lands. Procede was massive in scale, providing certificates to over 3.6 million families by the end of the program in 2006. In essence, Procede provides a large scale exogenous improvement in land tenure security, which we use to test the migration impact of property rights improvements.

Because the program provided certificates to the whole community simultaneously, we are in a rare position to use a fixed-effects econometric specification that compares *changes* in migration between households in early titled and later titled ejidos, and find that households in ejidos that obtain land titles are 28% more likely to have a migrant household member. The effects are larger for households with ex-ante weaker property rights (female headed households), and those with larger off-farm opportunities (those with more young male members). At the community level, titles lead to an overall reduction in population of 5%, and the effects are larger in lower land quality environments.

This migration result prompts the analysis of two important additional questions regarding agricultural land use. The first is whether there is evidence of sorting at the community level regarding who migrates and who does not? In this respect, we find evidence that farmers with larger land endowments are not more likely to migrate with the advent of the certification program. In contrast, it is the land-poor within the community that migrate more. This response is consistent with land being reallocated to its more productive members.

The second question is whether, with improvements in property rights, land-poor households simply decided to leave their farmland fallow, meaning that the certification program in the end led to a reduction in cultivated land. We use three rounds of satellite imagery data to determine that, on average, farmland in ejidos did not decrease after introduction of the program, lending

[1] Ejido lands consist of individual use agricultural plots, common use areas (forests, pastures, and surface water), and residential parcels.

credence to the hypothesis that labor productivity of those who stayed behind increased because they were each operating more farmland. Furthermore, we actually see a difference in land acreage under cultivation according to land quality: ejidos in high productivity land saw an increase in farmland after the certification program was introduced compared to those in low productivity land.[2] Finally, we show that changes in migration and changes in farmland acreage are related: farms with more outmigration are exactly those where agricultural land was reduced.

The remainder of the paper is organized as follows. In section 2 we provide further details on Procede. Section 3 develops some basic theory on the effects of property rights on migration. Section 4 discusses the data and identification strategy. Section 5 presents the results. Section 6 provides robustness checks and section 7 concludes.

2 The Titling Program

During the period from 1914 to 1992, Mexico's first land reform involved government expropriation of large private landholdings and redistribution of these tracts of land to groups of peasant farmers organized in agrarian communities called ejidos.[3] Once awarded, the land was managed by the assembly of farmers under the guiding hand of the state. Beneficiaries enjoyed usufruct rights to a land plot for individual cultivation, access to common-use land, and a residential lot.

With the objective of limiting land concentration, ejidatarios faced strict legal restrictions on rentals and sales of land.[4] Furthermore, the Constitution itself ruled that any individually tilled land that was not cultivated for more than two years or more was to be reassigned to a member of the community willing and able to do so, imposing a permanent "use it or lose it" restriction.

Giving access to land to those who are willing to cultivate it is an important objective of land redistribution programs. For example, the United States Homestead Act of 1862 and the Reclamation Act of 1902 only awarded title to the land after five years of actual and continuous residence in order to guard against dummy filings, speculation, and the accumulation of large estates (Coman, 1911). In contrast, the Mexican ejido imposed the use requirement permanently, potentially leading to inefficient tying of labor to the land.

[2] As measured by municipality level rainfed maize yield, Mexico's main and omnipresent crop.

[3] The program also certified land to indigenous communities. In the remainder of the paper we do not differentiate ejidos from indigenous communities.

[4] Although there is evidence that a black market for ejido lands was present in many parts of the country.

The land redistribution program, one of the largest in the world (Yates, 1981), eventually resulted in low agricultural productivity farms and high levels of poverty (de Janvry, Gordillo, and Sadoulet, 1997). With the advent of NAFTA, the Mexican government introduced a major Constitutional reform in 1992 to improve efficiency in the ejido by certifying individual land plots to current users. The reform was clearly intended to improve security of access to land in the ejido by delineating individual property boundaries within the ejido, thus encouraging long-term productive investments by ejidatarios in their land and allowing for a legal land rental and local sales market (Heath, 1990). The reform created Agrarian Tribunals to resolve conflicts over the issuance of certificates, created an ejido National Land Registry where individuals would be assigned parcels in the ejido, allowed rental and sales between ejidatarios, and established a well defined procedure to turn ejido certificates into full titles that could be sold to non-ejidatarios.

The program was massive in scale and took 13 years to complete. The registration process began with officials from the Agrarian Attorney's Office (PA) approaching ejido officials and offering information about Procede. An ejido assembly was called to approve initiation of the titling process. Except for a few conflict zones, the program progressed remarkably smoothly. After the first assembly, government officials from the National Institute of Statistics and Geography (INEGI) worked with the ejido to identify owners of plots and to produce digital maps of the ejido. Any disputes over property ownership had to be resolved during this stage of the process by the agrarian courts especially created to resolve such conflicts (Deininger and Bresciani, 2001). After all conflicts had been resolved, the maps showing individual ownership were submitted for approval at a final ejido assembly. Final approval resulted in issuance of certificates by the National Agrarian Registry (RAN) *simultaneously* to all rights-holders in the ejido.

3 Theory

We provide a very simple set up to motivate the empirical analysis on the effect of increased security on migration and its main dimensions of heterogeneity . We use the standard agricultural production model in which farm labor h_e produces expected output Y_e according to $Y_e = Ah_e^{\theta}$, where $0 < \theta < 1$, and A is a total factor productivity parameter. We incorporate migration as households having the option of supplying labor h_m in the non-farm market at the wage W_m, for

which they earn $W_m h_m$. Household utility is quasi-linear:

$$u(C, l) = \gamma C + v(l),$$

where C is consumption, l is leisure, and utility of leisure is concave ($v' > 0,\ v'' < 0$). Households are endowed with time T which is spent working on the farm, on wage labor off the farm, and on leisure, so that $T = h_e + h_m + l$ is the time constraint. The household's budget constraint is $C = I + W_m h_m + A h_e^{\theta}$, where I is non-labor income.

3.1 Traditional land insecurity model

The traditional argument for improving the security of access to land (for instance Besley and Ghatak (2010)) is that property rights insecurity reduces the expected product that the household reaps from farm labor. In particular, expected farm production becomes $Y_e = (1 - \tau) A h_e^{\theta}$, where $\tau \in [0, 1]$ reflects the degree of insecurity in property rights.

Obtaining the first order conditions of the household's problem and differentiating with respect to τ provides the following prediction:

$$\frac{\partial h_e}{\partial \tau} = \frac{h_e}{(1 - \tau)(\theta - 1)} < 0.$$

Thus, in the standard setup, improving property rights results in an increase in farm labor, and in consequence in agricultural production too.

3.2 Land insecurity and farm labor

In line with the context of the property rights in the Mexican *ejidos*, we instead incorporate land insecurity as a minimum number of hours that the family is required to allocate to farm labor in order to maintain use rights to the land: $h_e \geq \underline{h_e}$. When this restriction binds, although households allocate more time to the farm than under unrestricted optimization, it is still advantageous to allocate $\underline{h_e}$ to the farm as long as the average return to farm labor W_e is as large as the off farm wage, i.e., $W_e = Y_e / h_e = (1 - \tau) A \underline{h_e}^{(\theta - 1)} \geq W_m$. Note that in contrast to Field (2007), the asset subject to insecure property rights *is* the productive asset. In this restricted optimization, off-farm

labor is determined by the FOC:

$$\gamma W_m = v'(T - \underline{h_e} - h_m). \tag{1}$$

The Procede certificates can be interpreted as allowing the farmers to move from the restricted optimization situation to the unrestricted one, in which labor allocation is given by the FOC:

$$\gamma A\theta h_e^{\theta-1} = \gamma W_m = v'(T - h_e - h_m). \tag{2}$$

If the restriction was binding, farm labor *decreases with the improvement in property rights*. Note that even if Procede did not result in unrestricted optimization, a relaxation of the constraint has the same qualitative effect. In that case $dh_m = -d\underline{h_e}$: Any relaxation of the constraint leads to a direct effect in terms of increased outmigration.

The simple household production model can also be used to obtain comparative statics predictions resulting from household level heterogeneity in security of property rights and outside wages, and across ejido heterogeneity in land productivity.

3.3 Heterogeneity in informal property rights

Heterogeneity of the degree of land insecurity under the old regime can be thought of as heterogeneity in the $\underline{h_e}$ parameter. More insecure property rights are reflected in a higher $\underline{h_e}$. *Ceteris paribus*, this generates a higher migration response the more insecure property rights are in the old regime.

3.4 Heterogeneity in off-farm wages

The migration response to an increase in off-farm wage W_m is obtained by total differentiation of the equilibrium conditions. Under the constrained regime, equation (1), the migration response is:

$$\frac{\partial h_m}{\partial W_m} = -\frac{\gamma}{v''(T - \underline{h_e} - h_m)} > 0 \tag{3}$$

Under the unconstrained regime, equation (2), the labor allocation response is given by:

$$\frac{\partial h_e}{\partial W_m} = -\frac{1}{A\theta(1-\theta)h_e^{\theta-2}} < 0$$

$$\frac{\partial h_m}{\partial W_m} = -\frac{\gamma}{v''(T-h_e-h_m)} - \frac{\partial h_e}{\partial W_m} > 0 \tag{4}$$

Comparing (3) and (4) shows that households with better outside wage opportunities will optimally allocate less labor to the farm, hence generating higher levels of outmigration, with an improvement in property rights.

3.5 Heterogeneity in farm productivity

Differing farmland quality in the model can be understood as heterogeneity in the productivity parameter A. Under the constrained optimization (1), farm labor is predetermined by the need to protect property rights, and outmigration does not vary with differences in productivity across farms. In contrast, under the unconstrained regime (2), labor allocation responds to land productivity. In particular, totally differentiating the FOCs leads to:

$$\frac{\partial h_m}{\partial A} = -\frac{\partial h_e}{\partial A} = -\frac{h_e}{A(1-\theta)} < 0$$

This simply states that optimal farm labor is higher the higher the land productivity A. Hence farms with lower land productivity have more outmigration when moving from a restricted to an unrestricted property rights regime.

4 Data

In this section we provide a brief overview of the five datasets we use to test the various predictions of the theoretical model. We leave specific details on data construction to the appendix.

Our source of information on the rollout of Procede is a set of GIS ejido boundaries for 26,481 ejidos that completed the program during the period from 1993-2006.[5] The ejido contour maps were created during the certification process by INEGI and managed by RAN. The curve in Figure

[5]These data also include 246 ejidos that were in the process of certification but had not yet completed the program during 2007.

1 gives the share of these ejidos that had completed the program by each year from 1993-2006. The rollout of the program was quite rapid. Nearly half of all ejidos were fully titled by 1997 while all but a small subset of ejidos had completed the program by 2006. Figure 1 also shows the dates of the other data sets used: the Progresa surveys (ENCEL), the population censuses, the ejido censuses, and the land use maps. Figure 2 shows the rollout of Procede at the national level, helping visualize the extensiveness and geographical spread of the certifications.

We use the 1998-2000 ENCEL surveys administered in the randomized evaluation of Progresa to study migration behavior.[6] The ENCEL data consist of a panel of approximately 25,000 households located in 506 localities in the states of Guerrero, Hidalgo, Michoacan, Puebla, Queretaro, San Luis Potosi, and Veracruz. We matched the localities to ejidos using the coordinates of the centroid of the locality. We considered the locality to match to an ejido if the centroid of the locality was located inside the boundaries of one of the ejidos that was included in the database of ejido contours. This process matched 200 localities to 186 different ejidos.[7] Of these ejidos, 65 were titled in 1993-1996, 49 in 1997-1999, and 73 after 1999. It is the households in the ejidos certified in 1997-1999 that we use to identify the effect of certification on migration. The final data consist of an unbalanced panel of 7,577 households that were certified after 1996. Approximately 2.2% of these households had a migrant leave during 1997. Between 1998 and 2000 an additional 5.9% of households sent a migrant.

For the community level analysis, we use the 1990 and 2000 population censuses at the locality level from INEGI. Figure 1 shows that approximately 75% of ejidos completed the program between the two censuses. We matched locality centroids to ejidos using the spatial matching technique mentioned above. The final data used in the regressions is a balanced two year panel of population and certification status for 27,261 localities. These data cover all states of Mexico and therefore have broader geographic coverage than the panel of Progresa households. Figure 3 gives the distribution of population growth from 1990 to 2000 in these localities. 59.7% of the localities in ejidos experienced a decline in population during this period, loosing in aggregate 175,000 persons

[6]Progresa is the Mexican conditional cash transfer program started in 1997. The program is now referred to as Oportunidades. Progresa localities were selected to have more than 50 but less than 2,500 inhabitants and have a high marginality index as computed from the 1990 population census and the 1995 population count information. We use the 1998, 1999, and 2000 ENCEL surveys. The 1997 migration data were derived from recalls in the 1998 ENCEL survey. The 1997 ENCASEH baseline survey did not have comparable migration information.

[7]See appendix for more details of this matching process.

or 9.1% of their population over 10 years.

The fourth dataset we use is the ejido census (Censo Ejidal) from INEGI that was administered to all ejidos in Mexico in the years 1991 and 2007. The 1991 and 2007 matched surveys are not publicly available and were merged by INEGI specifically for this study. Because the Ejido Census data that were made available to us did not identify the ejido by name, we created a matching algorithm that builds on common variables in the two censuses and the RAN GIS contour maps to construct a matched dataset of 19,713 ejidos. The details of the matching algorithm are given in the appendix.

Finally, we use INEGI GIS land use maps for the whole country. The data consist of Series II, III, and IV of the INEGI land use/land cover maps. The data are based on a combination of Landsat imagery taken at 30m resolution during 1993, 2002, and 2007 and a series of field verifications by INEGI. The digital ejido boundaries were overlaid on the land use layers to create a panel of land use at the ejido level for the years 1993, 2002, and 2007. The median amount of agricultural land during 1993 in the ejidos titled in 1993-2006 is roughly 240 hectares, while the median share of total ejido area that is in agriculture is 27%. These figures rose slightly to 275 hectares and 32% in 2007.

5 Results

5.1 The impact of land titles on migration: Basic result

We establish our basic result that a change in property rights that controls for exclusion can lead to increased outmigration in three independent datasets. First, we consider the panel of households from Progresa, which contains detailed demographic variables and migration status of household members over the four years 1997-2000. The unit of analysis is the household and the dependent variable is an indicator for whether the household has a permanent migrant living outside the ejido. The main estimating equation is:

$$y_{ijt} = \delta Certif_{jt} + \gamma_j + \alpha_t + x'_{ijt}\beta + \varepsilon_{ijt}, \tag{5}$$

where y_{ijt} is an indicator for whether household i in ejido j has a permanent migrant by year t,[8] $Certif_{jt}$ is an indicator for whether the ejido j was certified at the beginning of year t, γ_j is an ejido fixed effect, α_t is a time fixed effect, x_{ijt} is a column vector of household level covariates, and ε_{ijt} is a random error term. This is a standard fixed effect regression where identification is coming from changes in migration behavior correlated to changes in certification status.[9] Any time-invariant ejido characteristic that is correlated with the program rollout is accounted for by the ejido fixed effects. The identifying assumption is therefore that any time-varying ejido characteristics that affect migration trends are orthogonal to the distribution of certificates. We provide support for the validity of this identification assumption in the next section.

The first column in Table 1 gives the basic result with no household controls. In this basic specification, the probability of a household having a migrant increases by approximately 0.015 after being reached by Procede. The magnitude of this estimate corresponds to an approximate 28% increase in the probability that a household has a migrant as a result of being certified. This happened against a background of intense migration. While in 1997 2.2% of the households had a migrant, the natural trend (year fixed effects in the regression) increased that number to 7.2% by 2000. Hence Procede is estimated to have contributed to an additional 28% in the number of new migrant households during these 3 years.

The second column shows that the estimated program effect is almost identical when household level covariates are included in the regression. The fact that certificates were distributed to all ejidatario households in the ejido is consistent with this minimal change when including household covariates. The third column shows that the estimated coefficient is essentially the same if ejido fixed effects are replaced by household fixed effects. Hence, the behavior of families in the Progresa dataset points to land certificates increasing the probability that a household member migrates.

Because the migration result using this dataset requires that at least one member of the household stays behind to report the migration behavior of other members, we also study migration

[8] Once a household has had a migrant leave, its value of y remains at one for the remainder of the sample period.

[9] Note that this specification does not exploit variation in the time that the household has held a certificate. A reasonable expectation is that the effect of holding a certificate on the probability of having a migrant is different for households that have held a certificate for different periods of time. An additional specification includes separate indicators for households certified in the last two years and households certified more than two years ago produced positive and significant coefficients at the 10% level on both variables. The coefficient on the indicator for being certificate for more than 2 years is only slightly larger, by roughly 8%. The difference in the coefficients is not significant (p-value=0.86). Given these insignificant differences, we focus on the binary measure of whether the household holds a certificate.

behavior at the community level using the matched 1990 and 2000 population censuses at the locality level. An advantage of this alternative dataset is its geographical coverage. It allows us to study migration behavior nationwide in all ejidos, not just in poor communities in the seven Progresa states.

By the year 2000, 73% of the ejidos had been awarded a certificate, while the other ejidos were still in the pre-certification regime. We first compare the evolution of their population in a standard two-period fixed effect regression:

$$Pop_{it} = \gamma_i + \beta I(t = 2000) + \delta I(Certified\ by\ 2000_i = 1) I(t = 2000) + \varepsilon_{it}. \tag{6}$$

We then allow for a linear effect of title over time by estimating:

$$Pop_{it} = \gamma_i + \beta I(t = 2000) + (\delta_0 + \delta_1 Years\ Certified_i) I(Certified\ by\ 2000_i = 1) I(t = 2000) + \varepsilon_{it}. \tag{7}$$

The dependent variable is the total population (or logarithm) of locality i in year t (1990 or 2000). The first specification (6) is a simple fixed effect regression where δ identifies the average effect of the ejido getting certification on the change in locality population. The second specification (7) takes into account the number of years since certification, allowing the migration response to take effect over several years in a linear way.

Regression results are reported in Table 2, where standard errors are clustered at the ejido level. The first row in the table shows that ejido localities lost around 12% of their population between 1990 and 2000 (the time effect). The coefficient on the interaction term in the second row (column 1) indicates that Procede was associated with an *additional reduction* in population of approximately 3 individuals, in a setting where the average locality has 67 individuals. Consistent with this, the coefficient from the second column, in which the dependent variable is logarithmic, shows that the average reduction in local population is 5%. The third column shows that the loss of population is progressive over time, with a decline of approximately 0.9% of the population per year after Procede certification. This last result suggests that the effect of certification on population size are not immediate, but rather occurs over time. Ubiquity of the emigration effect across the whole distribution of change in population is illustrated in Figure 4. The solid black line represents

the empirical distribution function for the change in population from 1990 to 2000 for localities in ejidos that were treated in between the two censuses. The dashed line represents localities in ejidos treated in 2000 or later.[10] The distribution for localities in untreated ejidos stochastically dominates that for treated localities. This indicates that the effect of certification on migration is not a feature of some specific localities but occurs throughout the distribution of population changes.

The locality level database captures movements of entire families rather than solely migration of household members. However, migration is not the sole factor affecting total population. One potential confounding factor is fertility. Galiani and Schargrodsky (2010) find that titling of an urban slum in Argentina caused households to reduce fertility. Although plausible in the Argentinian context, the age of the ejidatario population in Mexico makes a fertility response unlikely.

Finally, we analyze migration behavior using the 1991 and 2007 ejido censuses. By 2007, all the ejidos in our dataset had been certified. Hence we can only identify the effect of certification coming from the differential number of years an ejido has been certified. Furthermore, because the question was not asked in the first round, we can only perform a cross sectional regression. Our dependent variable is the question from the 2007 Ejido Census asking if the majority of young people leave the ejido. We estimate a cross-sectional regression of the form:

$$Y_{is} = \alpha + \gamma_s + \delta \, Years \;\; Certified_{is} + x'_{is}\beta + \varepsilon_{is}. \tag{8}$$

where γ_s are state fixed effects and x'_{is} is a column vector of ejido level covariates in 1991 (before Procede). The dependent variable Y_{is} is an indicator variable for whether the majority of young people emigrate from the ejido.

This is obviously a less well identified regression than those reported using the previous two datasets. However, this specification is justified by the result in Table 2 suggesting that the effect of certification is increasing over time. Second, the ejido census has the advantage that the unit of observation coincides perfectly with the group of interest, because questions are asked about the group of ejidatarios in each particular ejido. Finally, this is the only dataset we use not necessitating a geographical merge. Hence, we see this as a important verification of the results presented in the

[10] The top and bottom 5% of observations were removed for the graph.

previous two tables.

Results are reported in Table 3. Column (1) reports a positive association between the years since certification and the probability that the majority of young people emigrate from the ejido. This result is robust to the addition of ejido covariates measured in 1991 (column 2). Columns (3) and (4) suggest that most of this effect is driven by increased migration to the United States, consistent with the results reported in Valsecchi (2011). The average ejido had been titled 9.5 years in 2007, meaning that for the average ejido, the probability that a majority of young people would be leaving the ejido increased by 7.8% due to the Procede program.

By presenting results from three independent datasets, we seek to credibly establish that increased security of property rights generated by the assignment of land certificates led to increased migration from agrarian communities. The number of households having a migrant increased by 28%, the locality population declined by 5%, and ejidos were 0.35% more likely to report that a majority of their youth were leaving the community for every year they had been certified. Applying these results to the almost 2 million population of the localities matched to ejidos suggests that Procede would have been responsible for an outmigration of about 100,000 people in addition to the natural trend leading to a decline of 230,000 people.

These results should not be interpreted as suggesting a reduction in welfare. On the contrary, we interpret this as evidence that inefficient amounts of labor had been allocated to the land under the regime with more insecure property rights, that could now be reallocated to more beneficial activities.

5.2 Heterogeneity in pre-reform property rights security

Past work by anthropologists indicates that, prior to Procede, female ejidatarias held low status inside the ejido (Stephen, 1996; Deere and Léon, 2001; Hamilton, 2002). Stephen (1996, p.291) quotes an ejidataria from Oaxaca as stating, "Women don't participate in ejido assemblies. The men in our community don't let us participate in meetings. When we speak up in a meeting they laugh at us." Based on interviews conducted in four ejidos in northern and central Mexico, Hamilton (2002) points out that women were susceptible to expropriation by male relatives or friends of high level ejido officials. This anecdotal evidence is consistent with property rights being weaker for women prior to Procede.

We can analyze heterogeneity in migration response according to gender of the household head using the Progresa dataset. The results in Table 4 show that the effect of Procede on migration of household members is significantly larger for female headed households. The first column in the table reports the basic fixed effect specification. The second column allows for a differential time effect by gender of the household head. The coefficient on *Certified*HH head is Female* is positive and significant in both specifications. The magnitude of the coefficient is quite large. The subset of households with female heads is small but not trivial, consisting of around 10% of the population. The marginal effect of certification for these households represents an approximate doubling in the probability that the household has a migrant. These effects contrast with the much smaller impact for male-headed households.

This result is consistent with property right improvements brought about by land certificates having much larger effects for female headed households. In terms of the model, we interpret this as individuals with weaker property rights having to dedicate more labor to the farm to protect their rights under the old regime, and hence certificates leading to higher emigration responses in equilibrium.

5.3 Heterogeneity in off-farm opportunities

Heterogeneity in off-farm wage opportunities can be proxied by the number of young males in the household. This group has traditionally been the highest at risk of migration because their off-farm labor market opportunities are relatively better than those of women and the elderly (Massey and Espinosa, 1997).

The third and fourth columns in Table 4 allow the effect of Procede to vary by the number of male household members in the age bracket from 17 to 30. When the certification effect is decomposed into these two groups, it turns out that the average treatment effect is small and insignificant for households with no males in the 17-30 age bracket. By contrast, the estimated effect is 0.024 and significant at the 1% level for households with one young male member. This corresponds to an approximately 34% increase in the probability of having a migrant.[11]

[11] Most of the households in the sample had 0 or 1 male members in this age range in 1997 (53% of households have 0 male member 17-30 years old , 37% have 1 member, and 7% have 2 members).

5.4 Certification, sorting, and migration

We have shown that land certificates led to an increase in migration from agricultural communities. We now turn to the question of whether there is evidence of sorting in the migration behavior of households in the ejido. In particular, economic theory predicts that certification in the community should lead to increased outmigration among less productive farmers, whereas it improves opportunities on-farm for more productive farmers by allowing them to consolidate land. We do not have measure of farmer productivity, but can contrast areas of differential land productivity, and within each ejido households with smaller or larger farm operation. The underlying assumption is that farm operation is a good proxy for higher productive capacity.

We define agricultural land as high or low productivity using maize yield information at the municipality level from SAGARPA (Ministry of Agriculture), in which we partition land quality at the median yield of 1.29 ton/ha. We rank families in each ejido in the Progresa dataset according to their land holdings into those with more and less than the median land at baseline in 1997. If it is true that certification allows productive farmers to concentrate land, we should find evidence in the data that a) certification does not lead to more outmigration among relatively larger farmers, and b) this should only be true in ejidos with relatively more productive agricultural land. This is because land consolidation should not occur in ejidos with very low land productivity.

These results are presented in Table 5. First note that ejidos in low yield municipalities had more outmigration after certification than those in high yield municipalities (row 1). This is consistent with families in less productive areas deciding to migrate more with the arrival of land certificates as discussed in section 3.5. Second, note in the second row that in certified ejidos, families with more initial land do not increase their migration rates, and that this only occurs in high productivity areas. In low productivity areas, all households respond to certification of their land with increased migration. This was not the case before certification (row 3), at which time families with large and small landholdings were sending out migrants at the same rate. These results are robust to controlling for differential time trends by the two types of households (columns (2) and (4)). These results are consistent with model prediction according to which migration sorts households by on-farm productivity: more productive households stay on farm, whereas less productive households respond to improved security of tenure by having more members migrate.

5.5 Certification, land use, and migration

Having shown that certification led to outmigration from agricultural communities, and evidence consistent with more productive farmers staying behind to cultivate the land, we now wish to determine if land in the ejido used for agricultural purposes actually decreased or not. Security of tenure means that families could now leave the land fallow without risk of loss, in which case cultivated land would decrease. Alternatively, land could be rented out or sold to other community members by households with migrants, leading to no change in cultivated land.

For this, we use panel data from Landsat providing area cultivated at three points in time, 1993, 2002, and 2007 (INEGI GIS land use series II, III and IV). At each of the three points in time we observe the amount of land allocated to agriculture, pasture, forest, jungle, and thicket in the ejido.[12] We estimate the reduced form impact of getting certification on the logarithm of cultivated area in a standard fixed effect framework with panel data:

$$\log Agland_{jt} = \gamma_j + \alpha_t + \delta Certified_{jt} + \varepsilon_{jt}. \tag{9}$$

Results reported in column (1) of Table 6 show that certification had no effect on total area used for agriculture in Mexican ejidos. The coefficient is actually positive but very small (0.1%) and not significant. However, this overall effect masks heterogeneity in response for ejidos of different land qualities. In column (2), we see that cultivated land actually increased with certification in agriculturally favorable areas but decreased in poorer areas. In column (3), we further control for potential differential time trends in high and low yield areas. The result shows that certification is associated with an insignificant decline of cultivated land in low-yield regions. Point estimates range from -0.8 to -1.8%. In contrast, agricultural land increases with certification in regions favorable to agriculture. The point estimate ranges from 1.3 to 1.6%, and the difference between favorable and non-favorable areas is significant.

This suggests that migration driven by improved tenure security did not lead to a proportional fall in area dedicated to agriculture. Consistent with evidence that the most productive farmers stayed behind, we find that in high productivity areas agricultural land actually increased

[12] These classifications are at the broadest level. The data were further classified at finer sub-levels. These sub-levels are not relevant for our analysis.

with improvement in property rights, and this is consistent with an increase in agricultural labor productivity.

We showed in section 5.1 that improvements in property rights are associated with a decline in locality population. We conclude our analysis by verifying that the decline in population is actually taking place in areas where cultivated land decreased the most. For this analysis, we consider the overall change in log agricultural land between 1993 and 2007 using the Landsat data. The 10th and 90th percentiles of this measure are -0.17 and 0.54 log points. The median change in log of agricultural land in these data is .0001 while the mean is 0.111. To limit the influence of outliers, we use the rank of the ejidos in the distribution of change in cultivated land.[13] The first two columns of Table 7 repeat the basic fixed effects regression of the locality population on whether the ejido has been certified separately for the localities with agricultural land use change below and above the median value. The table shows that the negative effect of certification on population size is confined to localities that also saw the largest decreases in agricultural land. For these localities, certification is associated with a 7.6% loss of population. The results are also presented in Figure 5. The leftward shift in the empirical distribution for localities in ejidos that were certified early is more pronounced in areas with changes in log agricultural land less than the median value (left panel). In column (3), this correlation is further verified with an interaction with the continuous variable for the rank in the distribution of agricultural land change. The triple interaction is positive and of the same order of magnitude as the double interaction between certification and year 2000. Hence, localities with the most decline in agricultural land ($rank$ =0) experienced a decline in population of 9.4% in response to certification, while localities in ejidos with the largest increase in agricultural land saw no effect of certification on population.

Figure 6 reports the estimated marginal effect of certification, (i.e. $\delta = -0.0944 + 0.0993 rank$), across the whole range of changes in agricultural land, with the corresponding 95% confidence band. The vertical line corresponds to approximately the 43rd percentile. Above this value, localities are in ejidos that experienced an increase in crop land between 1993 and 2007, and below in ejidos that experienced a decline. The effect δ of certification is estimated to be negative in all but those ejidos with the largest relative increases in agricultural land, and statistically negative in about 60% of

[13]The value of the variable Rank corresponds to the empirical distribution function of the change in the logarithm of agricultural land.

the localities.

In summary, we interpret this last exercise as providing evidence that migration and land use are two sides of the same behavioral response induced by Procede. In areas of low land quality, land certification induced a strong migration response accompanied by a decline in cultivated land. In more favorable areas, only the less well endowed households responded with migration, while the larger farmers did not migrate, and total land in agriculture did not decrease. This suggests that some land reallocation occurred within the ejido from smaller to larger farmers. There is unfortunately no direct evidence on these transactions, but our results are certainly compatible with this interpretation.

6 Validity checks

We present several tests that support the validity of the basic analysis in the paper. The main threat to identification in the Progresa dataset is correlation between the timing of Procede and the time-path of migration in the ejido. The estimated average treatment effect would be biased if completion of Procede were correlated with pre-program changes in migration. To investigate the possibility of bias in program timing, we use a regression of *pre-program* changes in ejido level migration rates on indicators for the year Procede was completed:

$$\Delta y_{jt} = \gamma + \alpha_t + \sum_{k \geq t} \delta_k (Procede\ Year_j = k) + \varepsilon_{jt} \quad \forall t \leq Procede\ Year_j. \tag{10}$$

The dependent variable Δy_{jt} is the change in the average level of the has-migrant household indicator in ejido j from year $t-1$ to year t. The key independent variables are a set of dummy variables, $Procede\ Year_j = k$, for the year in which the program was completed in the ejido. Since the panel data covers only the years 1997 to 2000, only three such variables are necessary for the ejidos certified in 1999, 2000, or after 2000.[14] *Procede Year* effects that are jointly significant would indicate that year of program completion was correlated with pre-program changes in migration. The results are reported in Table 8. In the first column, we consider all the ejidos that completed Procede during or after the year 1998 (and hence did not appear as certified in the data until

[14]The base group would be ejidos certified in 1998 since we require the ejido to be certified at the start of the year to be considered as certified for that year.

1999), and regress the change in migration between the 1997 and 1998 surveys on the set of dummy variables for the year of Procede completion. In column two, we restrict the analysis to the 94 ejidos that were certified during or after the year 1999, and for which we therefore observe two pre-program periods 1997-98 and 1998-99. We regress changes in migration in these two periods on ejido fixed effects, period fixed effects, and the year Procede was completed. And similarly with three pre-treatment observations for the 76 ejidos certified in 2000 or after, in column (3). Lack of a significant correlation between the year of Procede completion and changes in ejido level migration rates over time provides evidence that pre-program time trends in migration were not correlated with completion of the program.

Another possibility is that the timing of Procede is correlated with sharp changes in migration prior to the program. If Procede was rolled out in response to sharp declines in migration prior to the program, then our estimate would simply reflect reversion to mean migration levels and not the desired treatment effect. Perhaps more likely, if households anticipated the program and reduced migration to oversee the certification process, then post-program returns to normal migration rates would confound our estimate. We estimate the following specification to consider this potential Ashenfelter dip effect,

$$y_{jt} = \gamma_j + \alpha_t + \beta_0 \, Year\ of_{jt} + \beta_1 \, Year\ before_{jt} + \beta_2 2\ \ Years\ before_{jt} + \varepsilon_{jt}, \tag{11}$$

where y_{jt} is average migration at the ejido level, and other variables are indicators for the year of, year before, and two years before program completion. The β coefficients indicate whether migration levels were significantly different than average in the ejido during the years directly before the program. The fourth column of Table 8 gives the results of estimating (11). The point estimates are small and statistically insignificant, yet the standard errors are large. An ideal result of the regression would be a set of precisely estimated zeros on the three indicator variables. While we can not reject large coefficients, it is reassuring that there are no obvious significant changes in migration in the years leading up to completion of the program. We interpret the combined results in the table as providing no clear evidence that our identification strategy is biased by correlation between program completion and pre-program migration.

Another potential issue of concern is attrition of households from the ENCEL survey. Since

migration recall from the 1998 survey was used to construct data for 1997, only households not being surveyed in 1999 and 2000 could bias results if attrition were non-random. Descriptively, 11.2% of households with an interview completed in 1998 did not have an interview completed in 1999. The percentage rose slightly to 12.7% in 2000.[15] In Table 9 we run the basic regression used to identify the role of Procede on migration, equation (5), on attrition. The coefficient of the certified variable is both insignificant and very small. There is therefore no evidence that the migration effect reported in the previous section is due to selective attrition.

7 Conclusions

Improving property rights over rural land by guaranteeing security of access has been the objective of certification programs recently pursued in several countries. While the main argument for these efforts is that they should increase investment and production, we show that if property rights were tied to actual land use in the previous regime, these policies can also induce increased outmigration from agricultural communities. We provide evidence on this phenomenon by analyzing the Mexican ejido land certification program which, from 1993 to 2006, awarded ownership certificates to 3.6 million farmers on about half the country's farm land.

We documented a strong migration response in agricultural communities that obtained certificates along both the intensive and extensive margins. Families that obtained certificates are 28% more likely to have a migrant household member and the overall locality population falls by 5%. These effects are increasing over time.

We also documented heterogeneity in migration response according to the ex-ante level of property rights insecurity (female headed households send more migrants after certification) and the level of off-farm opportunities (households with more young males respond more to certification). At the community level, we find that the migration response is larger in lower land quality environments.

There is also evidence of sorting within the community: larger (more productive) farmers stay, whereas land-poor farmers leave. This prompts the question of whether total acreage under cultivation decreased with the program. We found that, on average, cultivated land was not reduced because of the program, which is consistent with gains in agricultural labor productivity. Addition-

[15] We define attrition as the interview not being conducted for any purpose.

ally, we showed that in high productivity land, the certification program actually led to increases in cultivated land compared to low productivity areas. Overall, the evidence shows that improvement in the security of access to land via certification increases the efficiency of labor allocation across space by inducing low productivity farmers to migrate, while leaving higher productivity farmers in place and allowing them to consolidate land.

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Data Appendix

In this section we provide more details on construction of some of the data used in the analysis.

Progresa Data

Household level migration was taken from the 1998-2000 fall versions of the ENCEL survey. The survey was conducted each fall from 1998-2000 in the 506 localities that were part of the experimental evaluation of Progresa. Since no ejido identifiers were included in these data, we matched the 506 localities to ejidos using a spatial merge in ARCGIS. We only observe the coordinates of the centroid of each locality and therefore match localities to ejidos if the center of the locality is located inside the boundaries of the ejido. The digital maps of all ejidos certified from 1993-2006 were obtained from RAN. The spatial merge resulted in 234 of the localities falling into one of 219 different ejidos. [16] The number of households from the 1998 survey that fell inside ejidos as a result of this process is 13,212. Another 4,893 households were removed from the sample as a result of being in ejidos that were certified before 1997. Since permanent migration is being measured, trends in migration are unlikely to be the same in ejidos certified prior to 1997 as those certified later. These ejidos are removed for this reason. It is also important to note that the spatial matching approach does not result in a perfect match between households and ejidos. It is possible that while the centroid of a locality falls into a particular ejido, the outskirts of the locality fall into a different ejido. This is more likely to be an issue in localities that are large. We used census population data to construct the ratio of the population of the locality to the number of ejidatarios in the matched ejido. The matching is more likely to be inaccurate when the locality is large relative to the ejido. We therefore retained only the 200 localities with the lowest values of this metric. This amounted to removing an additional 742 households from the sample. The total number of ejidos in the sample is 127.

[16] This number is roughly consistent with half of Mexico's land being in ejidos. The large number of localities that were not matched to ejidos is therefore not a concern. The matching rate of 46% is actually in line with 50% of land being in ejidos.

1991 and 2007 Ejido Census

The 1991 and 2007 ejido censuses consist of a set of 28,752 ejidos that were surveyed in both 1991 and 2007. We were unable to obtain the name of each ejido due to confidentiality concerns. Further, the 2007 census did not contain information on the time of completion of Procede. A matching process was therefore necessary to make these data usable. The key information used were the state, municipality, and name of the locality where the majority of the ejidatarios live. We used this information along with some common key variables between the census data and the GIS database from RAN to match ejidos based on a 4-step process:

1. There were 22,473 ejidos for which the locality where a majority of the ejidatarios live is located inside the boundaries of the ejido. For these ejidos we were able to use our spatial merge between localities and ejidos to identify the corresponding ejido in the GIS database. There are of course numerous instances where the boundaries of an ejido contain more than one locality centroid. We were unable to include these ejidos in this matching round. This round matched a total of 14,128 ejidos.

2. The second round of matching is meant to partially correct for the fact that matching localities to ejidos in the previous step using only the centroid of the locality is imperfect. The reason for this is that the centroid of the locality could fall outside of the boundaries of the ejido even if there is substantial overlap between the locality and ejido. Further, ejidos with multiple disjoint patches of land pose problems to matching based on locality centroids and ejido boundaries. The distance between the locality centroid for each unmatched census ejido and the center of each unmatched ejido from the GIS database was calculated using a simple distance calculation in ARCGIS. An ejido from the GIS data was matched to an ejido from the census data if the locality where the majority of the ejidatarios live was the closest locality to the center of the ejido. Since this match is not perfect, we attempt to minimize errors by only retaining matches where the percentage difference between the number of ejidatarios in the 1991 census and the GIS database was between -46.8% and 29%.[17] This round generated an additional 1,787 matches.

[17] These numbers were chosen as the 10th and 90th percentiles of the percentage difference from the ejidos matched in the previous round.

3. In this round we considered the remaining unmatched ejidos for which the locality where the majority of the ejidatarios live is located inside the boundaries of the ejido. We defined a potential candidate match from the GIS database as an unmatched ejido that was located in the same state and municipality. For each of these potential matches we considered 4 metrics of comparison. The first was the similarity between the name of the locality where the ejidatarios live and the name of the ejido in the GIS database.[18] We generated a spelling similarity index using a combination of the COMPARE and SPEDIS functions in SAS. A match was identified for sufficiently low values of this index. The second metric was the distance between the centroid of the locality and ejido. The ejidos were considered to match if the distance was less than 5.1 kilometers.[19] The third metric was the number of ejidatarios. A match was determined using the same cutoffs as in the previous round. The final metric was the difference between the size of the ejido (in hectares) in the two datasets. The percentage cutoffs were -32.4 and 41.6. We required at least two of these criteria to be satisfied to identify a match between the ejidos. For each census ejido we selected the ejido from the GIS database which matched on the most of these criteria (from 2 to 4). In order to break ties we used the percentage difference in the number of ejidatarios. This round generated a total of 1,878 matches.

4. The fourth round of matches considers the census ejidos where it was stated that the locality where the majority of ejidatarios live is *not* inside the boundaries of the ejido. We used a similar process as in the previous round with only two modifications. First, similarities between the name of the locality and the ejido were not used. Second, the distance requirement was relaxed to 8.6 kilometers (25th percentile). This round generated 1,920 matches.

[18] It is common for ejido names to be the same as locality names in Mexico.
[19] This value was chosen since it was the 10th percentile in the list of candidate matches.

Tables

Table 1: Effect of Procede on Household Migration Behavior

	Progresa Households Matched to Ejidos		
	(1)	(2)	(3)
	Has Migrant	Has Migrant	Has Migrant
Certified	0.0149**	0.0158**	0.0153**
	(0.0061)	(0.0064)	(0.0062)
HH is Agricultural		0.0136***	
		(0.0044)	
Number Males 17-30 in HH		0.0195***	
		(0.0046)	
HH head is Female		0.0127	
		(0.0101)	
Age of HH head		0.0009***	
		(0.0002)	
Time Fixed Effects	Yes	Yes	Yes
Ejido Fixed Effects	Yes	Yes	No
HH Fixed Effects	No	No	Yes
Mean of Dep Variable	0.053	0.056	0.053
Number of Observations	27189	24533	27189
R squared	0.047	0.058	0.043

Standard errors that allow for clustering at the ejido level are reported in parentheses. Asterisks indicate statistical significance at the 1% ***, 5% **, and 10% * levels. Data include observations on all households in ejidos that completed the Procede process after 1996. All regressions are linear probability models. The dependent variable is 1 if the household had a migrant leave during the year or any previous sample year. Certified indicator = 1 if ejido was certified at the start of the year.

Table 2: Effect of Procede on Locality Level Population, 1990-2000

	Census Localities Matched to Ejidos		
	(1) Population	(2) ln(Population)	(3) ln(Population)
Year=2000	-4.6213***	-0.1184***	-0.1184***
	(0.6590)	(0.0108)	(0.0108)
Certified 1993-1999*Year=2000	-2.8587***	-0.0506***	-0.0196
	(0.7590)	(0.0130)	(0.0187)
Years Certified in 2000*Certified 1993-1999*Year=2000			-0.0086**
			(0.0037)
Ejido Fixed Effects	Yes	Yes	Yes
Mean of Dep Variable	66.918	3.437	3.437
Number of Observations	54522	54522	54522
R squared	0.004	0.007	0.007

Standard errors that allow for clustering at the ejido level are reported in parentheses. Asterisks indicate statistical significance at the 1% ***,5% **, and 10% * levels. Data consist of 27,261 localities that were matched to ejidos and had population data in both the 1990 and 2000 censuses.

Table 3: Effect of Procede on Ejido-Level Migration of Young People

	Matched Ejidos in 1991 and 2007 Ejido Census			
	(1) Migrate	(2) Migrate	(3) Migrate US	(4) Migrate US
Years Certified in 2007	0.0035***	0.0039***	0.0037***	0.0031***
	(0.0013)	(0.0013)	(0.0012)	(0.0012)
Using Improved Seeds in 1991		-0.0178*		0.0009
		(0.0100)		(0.0095)
Using Tractors in 1991		-0.0048		0.0123
		(0.0105)		(0.0104)
Electrical Lighting in 1991		0.0384***		0.0514***
		(0.0108)		(0.0110)
Log of Distance Between Ejido and PA Office		0.0528***		0.0110
		(0.0113)		(0.0113)
State Fixed Effects	Yes	Yes	Yes	Yes
Mean of Dep Variable	0.426	0.426	0.297	0.297
Number of Observations	19670	19600	19670	19600
R squared	0.086	0.092	0.128	0.131

Standard errors that allow for clustering at the municipality level are reported in parentheses. Asterisks indicate statistical significance at the 1% ***, 5% **, and 10% * levels. The dependent variable in columns 1 and 2 is an indicator for the majority of the young people leaving the ejido. The question in the 2007 census identifies the ejidos where a majority of young people are integrated in the activities of the ejido or remain in the ejido but work in nearby localities. Finally, if neither of the prior conditions was true, the destination of the majority of the young people is identified. The variable "migrate" takes on a value of 1 if neither of the first two conditions was true. The dependent variable in Column 3 and 4 takes on a value of 1 only if the answer to the location of the majority of young people was the United States.

Table 4: Heterogeneous Effects of Certification on Migration

	Progresa Households Matched to Ejidos				
	(1) Has Migrant	(2) Has Migrant	(3) Has Migrant	(4) Has Migrant	(5) Has Migrant
Certified	0.0102	0.0097	0.0053	0.0060	-0.0014
	(0.0063)	(0.0064)	(0.0079)	(0.0084)	(0.0077)
Certified*HH head is Female	0.0581**	0.0632**			0.0624**
	(0.0247)	(0.0277)			(0.0248)
Certified*Number of Males 17-30			0.0191*	0.0181	0.0206**
			(0.0103)	(0.0113)	(0.0102)
HH is Agricultural	0.0149***	0.0149***	0.0128***	0.0128***	0.0137***
	(0.0044)	(0.0044)	(0.0044)	(0.0044)	(0.0044)
Age of HH head	0.0008***	0.0008***	0.0009***	0.0009***	0.0009***
	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0002)
HH head is Female	0.0012	0.0058			0.0015
	(0.0090)	(0.0082)			(0.0090)
Number Males 17-30 in HH			0.0157***	0.0151***	0.0156***
			(0.0043)	(0.0056)	(0.0043)
Time Effects	Yes	Yes	Yes	Yes	Yes
Ejido Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Effects*Has Males 17-30	No	No	No	Yes	No
Time Effects*HH Head is Female	No	Yes	No	No	No
Mean of Dep Variable	0.056	0.056	0.056	0.056	0.056
Number of Observations	24533	24533	24533	24533	24533
R squared	0.055	0.055	0.058	0.058	0.060

Standard errors that allow for clustering at the ejido level are reported in parentheses. Asterisks indicate statistical significance at the 1% ***, 5% **, and 10% * levels. Data include observations on all households in ejidos that completed the Procede process after 1996. All regressions are linear probability models. Dependent variable = 1 if the household had a migrant leave during the year or any previous sample year. Certified indicator = 1 if ejido was certified at the start of the year.

Table 5: Heterogeneity in Certification Effect According to Baseline Land

	High Yield Municipalities		Low Yield Municipalities	
	(1)	(2)	(3)	(4)
	Has Migrant	Has Migrant	Has Migrant	Has Migrant
Certified	0.0156*	0.0198**	0.0357***	0.0378***
	(0.0090)	(0.0099)	(0.0130)	(0.0128)
Certified * Land per Adult > Median in Ejido (1997)	-0.0238*	-0.0337**	-0.0109	-0.0163
	(0.0124)	(0.0158)	(0.0157)	(0.0164)
Land per Adult > Median in Ejido (1997)	0.0113	0.0015	0.0018	-0.0031
	(0.0073)	(0.0057)	(0.0054)	(0.0047)
Age of HH head	0.0007***	0.0007***	0.0011***	0.0011***
	(0.0002)	(0.0002)	(0.0003)	(0.0003)
HH head is Female	0.0202	0.0202	-0.0045	-0.0045
	(0.0145)	(0.0145)	(0.0134)	(0.0134)
Ejido Fixed Effects	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes
Time Effects*Land per Adult > Median in Ejido	No	Yes	No	Yes
Mean of Dep Variable	0.057	0.057	0.054	0.054
Number of Observations	14533	14533	9839	9839
R squared	0.049	0.049	0.062	0.063

Standard errors that allow for clustering at the ejido level are reported in parentheses. Asterisks indicate statistical significance at the 1% ***, 5% **, and 10% * levels. Dependent variable in all regressions is 1 if the household is a migrant household. Certified indicator = 1 if ejido was certified at the start of the year. All regressions are linear probability models. Columns 1 and 2 are for ejidos in municipalities with average maize yields above 1.293 tons/hectare. Columns 3 and 4 limit to ejidos in municipalities with average maize yields below 1.293 tons/hectare.

Table 6: Effect of Procede on Agricultural Land Use

	Ejido-Level Panel Using LANDSAT Satellite Data		
	(1)	(2)	(3)
	Log(Area Ag.)	Log(Area Ag.)	Log(Area Ag.)
Certified	0.0013	-0.0080	-0.0175
	(0.0093)	(0.0108)	(0.0136)
Certified * High Yield		0.0209**	0.0332*
		(0.0093)	(0.0182)
Ejido Fixed Effects	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes
Time Effects*High Yield	No	No	Yes
Mean of Dep Variable	5.718	5.714	5.714
Number of Observations	63392	58763	58763
R squared	0.012	0.012	0.012

Standard errors that allow for clustering at the ejido level are reported in parentheses. Asterisks indicate statistical significance at the 1% ***, 5% **, and 10% * levels. The dependent variable is the log of the area in agriculture in the ejido. *High Yield* is 1 if 2002-2007 average maize yield is larger than 1.293.

Table 7: Population Regressions by Change in Agricultural Area

	Rank>0.5	Rank<0.5	All
	(1)	(2)	(3)
	ln(Population)	ln(Population)	ln(Population)
Year=2000	-0.1523***	-0.1194***	-0.1097***
	(0.0148)	(0.0207)	(0.0260)
Certified 1993-1999*Year=2000	-0.0144	-0.0764***	-0.0944***
	(0.0189)	(0.0237)	(0.0305)
Rank of Ag Change * Year=2000			-0.0538
			(0.0398)
Rank of Ag Change * Certified 1993-1999 * Year=2000			0.0993**
			(0.0483)
Ejido Fixed Effects	Yes	Yes	Yes
Mean of Dep Variable	3.378	3.557	3.455
Number of Observations	24526	18454	42986
R squared	0.007	0.009	0.008

Dependent variable in all regressions is log of locality population. Standard errors that allow for clustering at the ejido level are reported in parentheses. Asterisks indicate statistical significance at the 1% ***,5% **, and 10% * levels. Data come from the 1990 and 2000 locality population censuses. The first column limits to localities in ejidos that experienced above the median change in log agricultural area from 1993-2007. The second column limits to localities in ejidos that experienced below the median changes. The final column is for all localities in ejidos that had nonzero agricultural land area in both 1993 and 2007.

Table 8: Relationship Between Procede and Pre-Program Migration

	Progresa Households Matched to Ejidos, Pre-Program Period			
	(1)	(2)	(3)	(4)
	Δ Mig Rate	Δ Mig Rate	Δ Mig Rate	Mig Rate
Procede Completed in 1999	-0.0011			
	(0.0113)			
Procede Completed in 2000	-0.0040	-0.0087		
	(0.0110)	(0.0092)		
Procede Completed After 2000	-0.0131	-0.0102	0.0015	
	(0.0090)	(0.0086)	(0.0046)	
Year Procede Completed (0/1)				0.0018
				(0.0150)
Year Before Procede (0/1)				-0.0021
				(0.0107)
2 Years Before Procede (0/1)				-0.0015
				(0.0089)
Time Fixed Effects	No	Yes	Yes	Yes
Ejido Fixed Effects	No	No	No	Yes
Mean of Dep Variable	0.022	0.020	0.018	0.050
Number of Observations	111	187	225	406
Number of Ejidos	111	94	76	127
R squared	0.047	0.019	0.002	0.774
Pvalue of joint test	0.190	0.493		

Standard errors are reported in parentheses. Robust standard errors are used in column 1. In columns 2-4, standard errors are clustered at the ejido level. Asterisks indicate statistical significance at the 1% ***, 5% **, and 10% * levels. The dependent variable in columns 1-3 is the change in ejido migration rate. The dependent variable in column 4 is the ejido migration rate. Both regressions are for the pre-treatment period. Columns 1 is for for 1998. Column 2 is for 1998-1999. Column 3 is for 1998-2000. Column 4 is for 1997-2000.

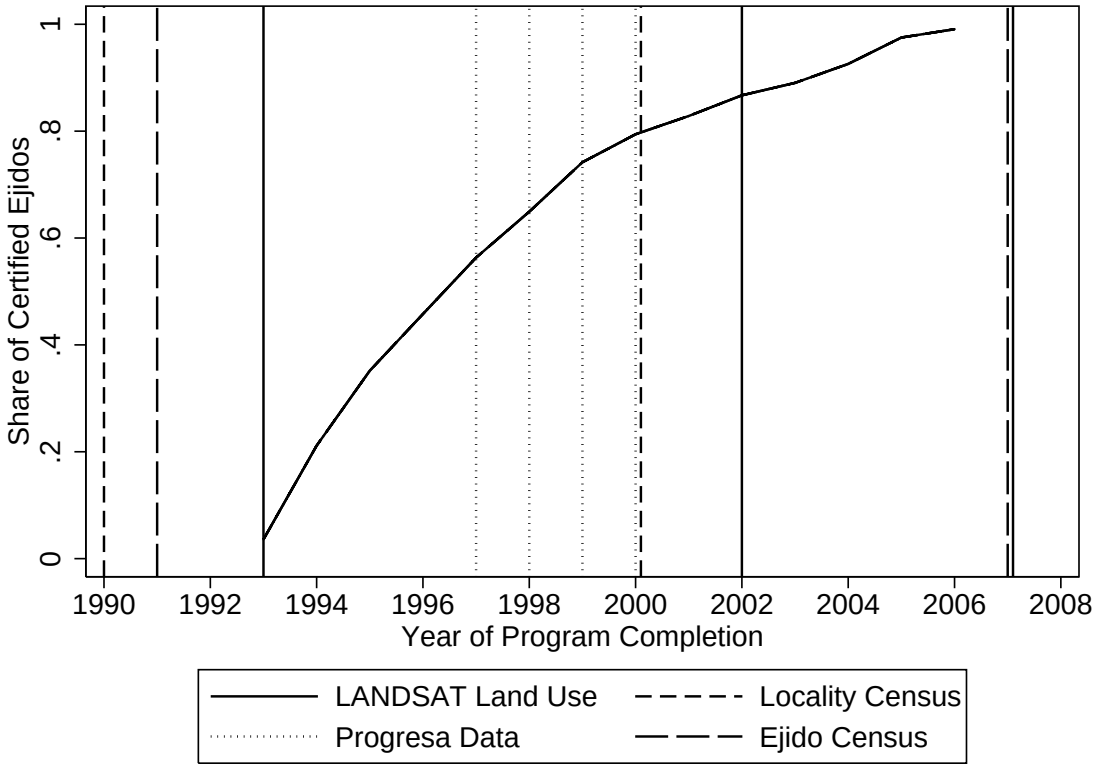
Table 9: Regressions of Attrition on Certification Status and Household Covariates

	(1) Attrition Indicator
Certified	-0.003
	(0.025)
HH is Agricultural	-0.043***
	(0.010)
Number Males 17-30 in HH	0.005
	(0.004)
HH head is Female	0.030**
	(0.012)
Age of HH head	-0.000
	(0.000)
Ejido Fixed Effects	Yes
Time Fixed Effects	Yes
Mean of Dep Variable	0.112
Number of Observations	12895
R squared	0.115

Standard errors that allow for clustering at the ejido level are reported in parentheses. Asterisks indicate statistical significance at the 1% ***, 5% **, and 10% * levels. Data are for all households that were surveyed in the Fall 1998 ENCEL survey. Observations are from 1999 and 2000. Dependent variable = 1 if household did not have survey completed. Certified indicator = 1 if household held title at the start of the year. 446 households attrited in 1999 but not in 2000. 331 households attrited in both 1999 and 2000. 554 households attrited in 2000 but not in 1999.

Figures

Figure 1: Correspondence Between Data and Rollout of Procede



The Progresa ENCEL data are from 1998-2000. Migration recall data were used for 1997. Locality level census data are from 1990 and 2000. Ejido level census data are from 1991 and 2007. LANDSAT land use data are from 1993, 2002, and 2007.

Figure 2: Map of Survey Localities and Rollout of Procede

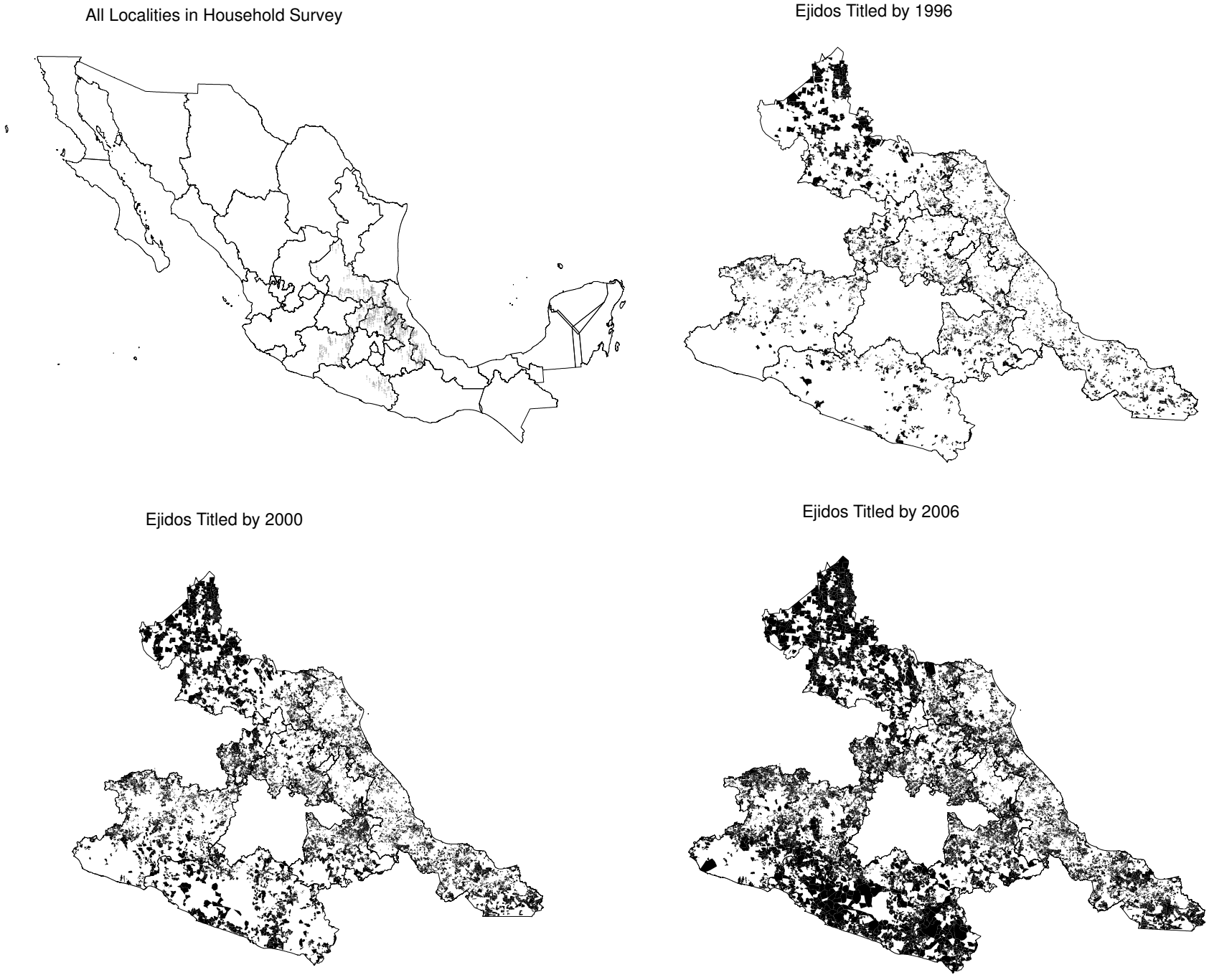


Figure 3: Distribution of Population Growth in Ejido Localities, 1990-2000

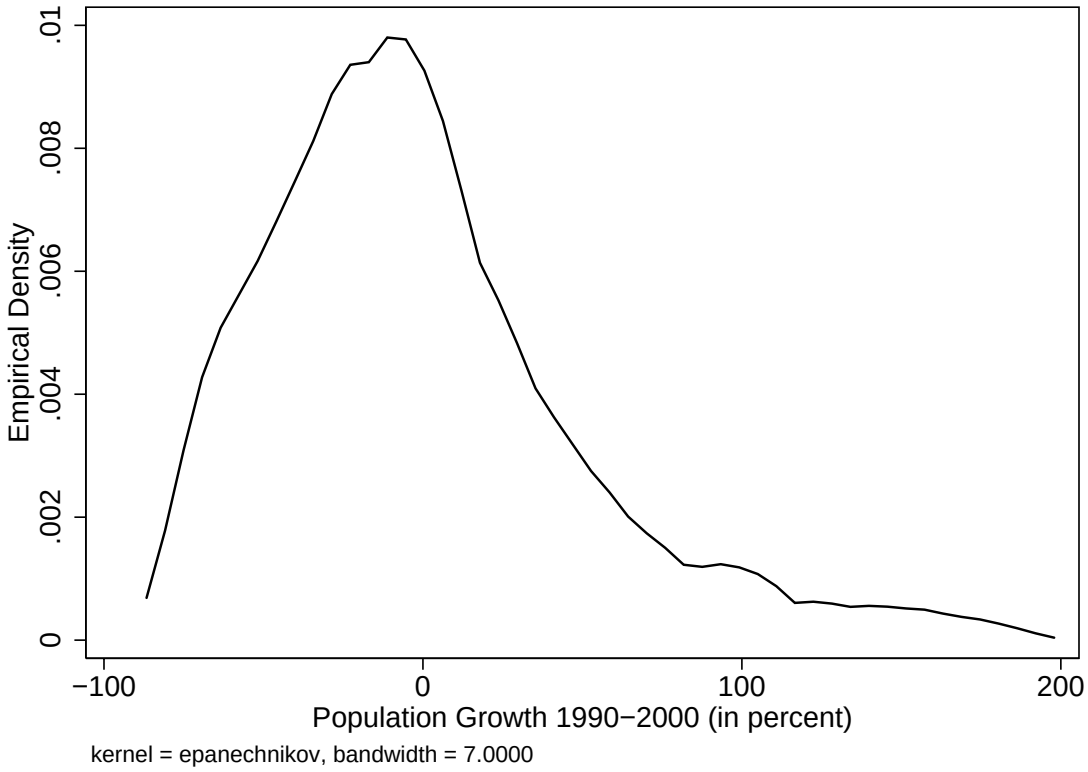


Figure 4: Cumulative Distribution of Population Growth, 1990-2000, by Certification Date

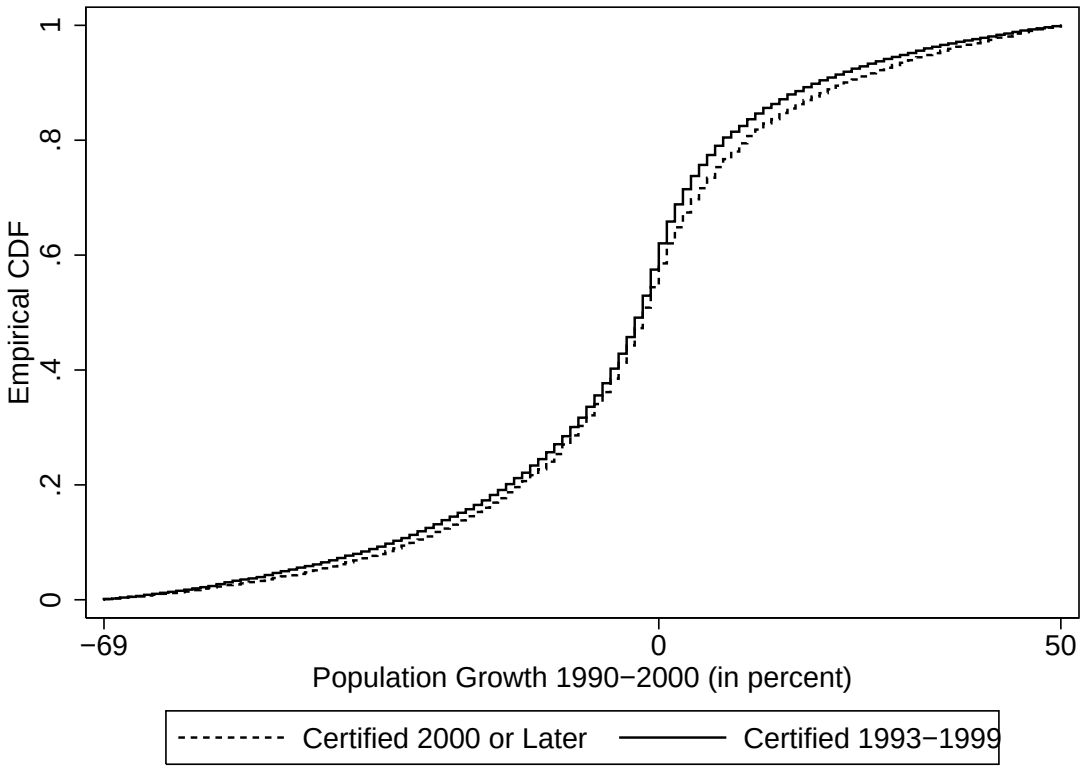


Figure 5: Empirical Distribution of Change in Population from 1990-2000, by Rank of Change in Log Agricultural Area from 1993-2007

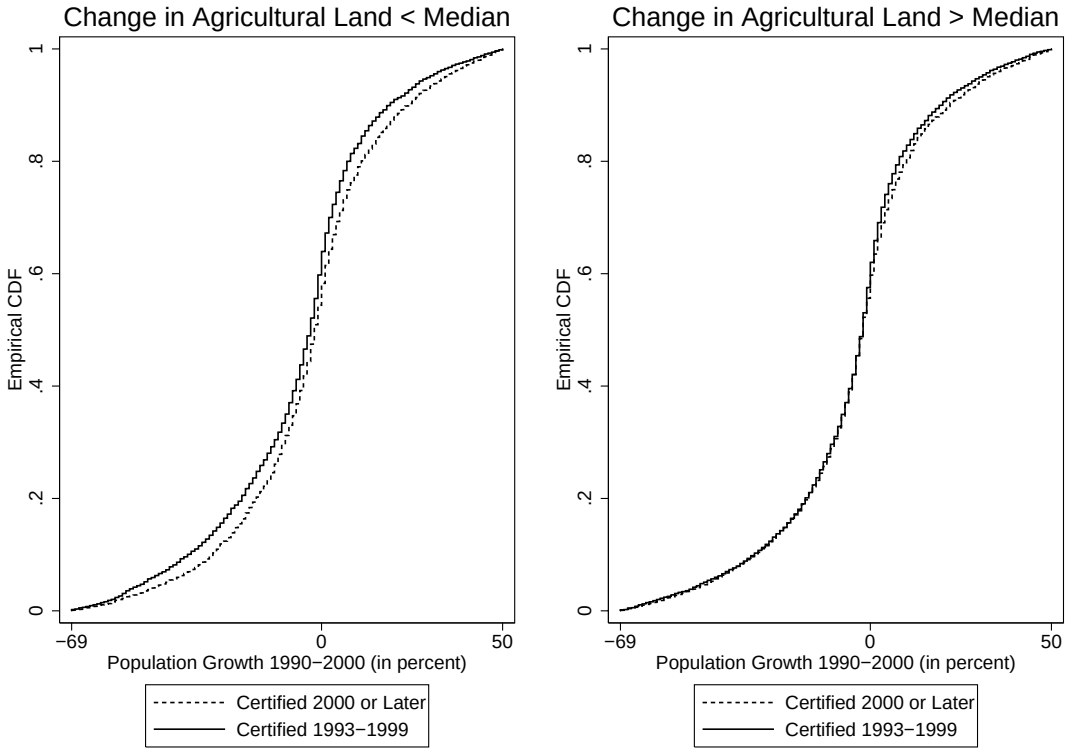


Figure 6: Differences-in-Differences Estimates of Certification on Log Population by Rank of Change in Log Agricultural Area from 1993-2007