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 obtaining land certificates were 30% 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 4% reduction in population. 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 areas.

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1 Introduction

The ability to exclude others from encroaching on land is a key aspect of a complete and well-defined property right (Ostrom, 2001). Incomplete property rights in which the right of exclusion is missing or uncertain result in insecurity of continued access to land. Typical of this situation are squatter and usufruct rights that are contingent on active use to defend the asset against seizure by others. The negative effects of this insecurity on economic development are well noted.

In this paper, we focus on an unexplored aspect of improved land rights in rural areas, which is their effect on migration. The classical argument for improving property rights suggests that such improvements will lead to an overall increase in labor allocated to agriculture given complementarity between productive investments and farm labor. However, if presence of the owner or active use of the land by the owner is necessary to demonstrate property rights, then labor may be inefficiently tied to land. The active use requirement creates a distortion working in the opposite direction. We use a simple household model to show that the introduction of a land certification program severing the link between use and ownership is likely to lead to increased outmigration.

We test this hypothesis using data from Mexico's large-scale land certification program (Programa de Certificación de Derechos Ejidales y Titulación de Solares, or Procede). The Procede program was rolled out nationwide from 1993-2006 to issue certificates of ownership over ejido land. Ejidos are agrarian communities that were created starting in 1914 as part of an ambitious land reform program in which members (ejidatarios) were granted usufruct rights over individual plots and common use lands. Security of access for individuals was however limited. Any land that was left fallow for more than two years could be reassigned to another person, or plots could be reassigned under simple majority agreement of other members of the community. Procede gave ejidatarios land certificates declaring the name of the owner of each agricultural plot alongside a GIS map of the plot. Similar documents were provided 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 institutional change from use-based ownership to certificate-based ownership. We use this large-scale land certification program to test the migration impact of improvements in property rights.

Because the program provided certificates to the entire community simultaneously, we are in a position to use a fixed-effects econometric specification that compares *changes* in migration between households in early certified and later certified ejidos. We establish the migration result using three independent datasets. Using a survey of households over time, we find that households in certified ejidos are 30% more likely to have a migrant household member. Using a community level dataset, we find that certificates lead to a 4% reduction in population. Thirdly, we use a nationwide ejido census to confirm that certification lead to more young people leaving the ejido for work reasons. We further document a larger migration response for households with ex-ante weaker property rights and those with more attractive off-farm wage potential.

The 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. In this respect, we find evidence that farmers with larger land endowments are less likely to migrate as a result of the program. The model predicts this differential magnitude, as the use restriction in the insecure property rights regime is more onerous for farmers with smaller landholdings.

The model suggests that the difference in migration response between large and small landholders should be sharper in areas with higher land productivity. We find clear evidence of this in the data. The overall effect of certification for land-rich households in high productivity areas is not statistically different from zero. This suggests that households are sorted according to their landholdings: larger, more productive farmers stay on the farm, whereas smaller more marginal farmers respond to improved security of tenure by having more members migrate. This result has important implications for studies on impacts of land tenure programs on agricultural productivity. Migration of less productive farmers could create a selection effect causing an upward bias of productivity estimates.

Our final question is whether more secure property rights caused households to simply leave their farmland fallow, meaning that the certification program led to a reduction in cultivated land. An alternative explanation is that land markets were working to reallocate land from those who left to those who stayed behind, so that acreage under cultivation did not decrease. We use three rounds of satellite land use data to determine that, on average, farmland in ejidos did not decrease after introduction of the program. The minimal change in cultivated land lends credence to the hypothesis that the labor productivity of farmers staying behind increased because they were operating more farmland. Furthermore, we actually see a difference in land acreage under cultivation according to land quality: ejidos in high land productivity areas saw an increase in farmland after the certification program was introduced compared to those in low productivity areas. Finally, we show that changes in migration and changes in farmland acreage are related: areas with more outmigration after certification are exactly those where agricultural land was reduced.

The closest papers to ours are Field (2007) and Galiani and Schargrodsky (2010), both of which study the effect of improved property rights on labor reallocation in urban areas. Field (2007) finds that providing land titles to urban squatters in Peru results in a decrease in the amount of labor allocated to home work and a corresponding increase in the amount of labor supplied to work away from home. Galiani and Schargrodsky (2010) find that the provision of land titles to squatters in urban Argentina led to decreases in household size, but had no effect on labor market outcomes. Our work focuses on rural areas and on actual migration rather than labor allocation.

This research also fits in a broader literature on the effects of land reform. The effects of improving land tenure security on investment and production have been discussed in Besley (1995), Alston, Libecap, and Schneider (1996), Jacoby, Li, and Rozelle (2002), Field (2005), Deininger and Jin (2006), and Goldstein and Udry (2008). The agricultural productivity effects of exclusion rights were further studied by Hornbeck (2010) using the case of barbed-wire in the US midwest.. In a similar study, Libecap and Lueck (2011) show that the rectangular system of land demarcation offers a clearer definition of ownership and therefore results in fewer land disputes and increases in land values. The effects of improved property rights on land markets are documented in Ravallion and Van de Walle (2003), Do and Iyer (2008) and Macours, de Janvry, and Sadoulet (2010).

The remainder of the paper is organized as follows. In Section 2 we provide further details on Procede. Section 3 develops a basic household model and derives testable implications. Section 4 discusses the data and identification strategy. Section 5 presents the results. Section 6 provides robustness checks and section 7 concludes.

2 The *Procede* Land Certification 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 (Sanderson, 1984).[1] 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 (for example forests, pastures and surface water), and a residential lot. With the objective of limiting land concentration, ejidatarios faced strict legal restrictions on rentals and sales of land.[2] Furthermore, the Constitution itself ruled that any individually tilled land that was not cultivated in two consecutive years was to be reassigned to a member of the community willing and able to cultivate the land, 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 landholder 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. Political scientists have argued that providing small plots that could not be consolidated was purposefully done to create a clientelistic relationship between farmers and the party in power, in spite of the economic inefficiencies it entailed (Magaloni, 2006).[3]

This first land redistribution program, one of the largest in the world (Yates, 1981), eventually resulted in low agricultural productivity 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 (Heath, 1990). The reform created Agrarian Tribunals to

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

[2] Although there is evidence that a black market for ejido lands existed in some parts of the country (Cornelius and Myhre, 1998).

[3] In a recent paper, we find evidence of voting behavior consistent with that hypothesis (de Janvry, Gonzalez-Navarro, and Sadoulet, 2011).

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.[4]

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 certification 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 GIS 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.[5]

3 Theory

The traditional land insecurity model treats insecurity of property rights similarly to a tax on production. Because improving property rights in the canonical model leads to a higher expected output, this naturally leads a household to optimally allocate more labor to the farm, i.e. reducing the equilibrium level of outmigration.

In this section, we instead model land insecurity as a requirement to cultivate the land in order to maintain property rights. This, together with the prohibition of land sales and rentals, prevents farms from operating at an efficient scale. The model seeks to make clear how these two requirements can cause inefficient tying of labor to land, and how relaxing those restrictions can provoke increased outmigration. Once that is established, the model is used to generate predictions about heterogenous effects which can be taken to the data.

[4] See de Ita (2006) for a description of the reforms.

[5] Appendini (2002) provides a thorough description of the certification process.

3.1 Setup

We use the standard agricultural production model in which farm labor h_e produces expected output Y_e according to $Y_e = \gamma A^\alpha h_e^\beta$, where $0 < \alpha, \beta < 1$, A is land, and γ 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:

$$u(C, \ell) = C + v(\ell),$$

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 $T = h_e + h_m + \ell$ is the time constraint. The household's budget constraint is $C = \gamma A^\alpha h_e^\beta + w_m h_m + I$, where I is non-labor income.

3.2 Traditional land insecurity model

Insecure property rights are usually modeled as reducing the expected product that the household reaps from farm labor (for instance Besley and Ghatak (2010)). In particular, expected farm production becomes $Y_e = (1-\tau)\gamma A^\alpha h_e^\beta$, 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:

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

Thus, in the standard setup, improving property rights results in an increase in farm labor and a corresponding decrease in migration.

3.3 When farm labor preserves property rights to the land

In line with the context of the property rights in the Mexican ejidos, we instead incorporate land insecurity as a minimum production level per unit of land:

$$\frac{Y_e}{A} \geq \frac{\pi_m}{s},$$

where π_m is the minimum yield, and $s \in (0, 1)$ is a parameter representing the household's specific strength of property rights. The parameter s captures the idea that households with weaker property rights have to maintain a higher production level to keep their land. Because we do not have stochastic output, the minimum yield requirement can alternatively be thought of as a minimum labor requirement per unit of land. However, in deference to the principal-agent literature, we use the minimum yield requirement as it is more realistic.

In line with the rules regulating the ejido sector in Mexico, there is neither rental nor sales markets for land, and farmers are not allowed to hire workers. Hence A is the exogenously allotted land to the household during the first land reform, and h_e can only be family labor. Lack of land markets and farm sizes below the optimal scale can be thought of as generating non-decreasing return to scale ($\alpha + \beta \geq 1$). Non-decreasing returns to scale can arise out of small landholdings or production indivisibilities. In any case, there is evidence for this assumption in Mexican ejidos.[6]

Without constraint, the optimal allocation to farm production would be:

$$h_e^* = \left(\frac{\gamma\beta}{w_m}\right)^{\frac{1}{1-\beta}} A^{\frac{\alpha}{1-\beta}}, \tag{1}$$

which is an increasing and convex function of A. The minimum yield constraint requires the household to allocate a minimum amount of labor ($\underline{h_e}$) to agricultural production.

$$\underline{h_e} = \left(\frac{\pi_m}{s\gamma}\right)^{\frac{1}{\beta}} A^{\frac{1-\alpha}{\beta}}, \tag{2}$$

[6] The 1994 ejido survey was administered to around 1300 ejido households by the World Bank. We estimated a production function of the form $ln(production_{is}) = \beta_0 + \beta_1 ln(hectares_{is}) + \beta_2 ln(labor_{is}) + \alpha_s + \varepsilon_{is}$, where i indexes households and s indexes states. Standard errors were conservatively clustered at the state level. The estimates from this regression are $\hat{\beta}_1 = 0.933$ and $\hat{\beta}_2 = 0.176$. The sum of the two coefficients is significantly larger than 1 with a p-value of 0.048. While these estimates certainly can not be interpreted causally, the results provide some suggestive empirical evidence consistent with non-decreasing returns to scale in Mexican ejidos.

or else lose its land. This minimum labor requirement is an increasing and concave function of A. The restriction will bind for farm sizes that are smaller than the threshold A_0 defined by $h_e^* = \underline{h_e}$:

$$A_0 = \left[\frac{1}{\gamma}\left(\frac{\pi_m}{s}\right)^{1-\beta}\left(\frac{w_m}{\beta}\right)^{\beta}\right]^{\frac{1}{\alpha+\beta-1}}. \tag{3}$$

At the constrained labor allocation, the average on-farm return to labor is:

$$\frac{Y_e}{h_e} = \gamma A^{\alpha} h_e^{\beta-1} = \gamma^{\frac{1}{\beta}}\left(\frac{\pi_m}{s}\right)^{1-\frac{1}{\beta}} A^{\frac{\alpha+\beta-1}{\beta}},$$

When the 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 is as large as the off farm wage, i.e., $Y_e/h_e \geq w_m$. This defines a threshold A_1 below which households will prefer to lose their land and fully work off-farm:

$$A_1 = \left[\frac{1}{\gamma}\left(\frac{\pi_m}{s}\right)^{1-\beta} {w_m}^{\beta}\right]^{\frac{1}{\alpha+\beta-1}} = \beta^{\frac{\beta}{\alpha+\beta-1}} A_0 \tag{4}$$

Equilibrium Labor Allocation. *The labor allocation solution to this restricted optimization is represented in Figure 1 and summarized as follows:*

- Leisure is determined by: $w_m = v'(\ell)$
- On farm labor is given by:

  (i) $h_e = h_e^*$, if $A \geq A_0$

  (ii) $h_e = \underline{h_e}$, if $A_1 \leq A \leq A_0$

  (iii) $h_e = 0$, if $A \leq A_1$,

  where A_0 is defined by $h_e^* = \underline{h_e}$, and A_1 is defined by $Y_e/h_e = w_m$
- Migrant/off-farm labor is given by:

$$h_m = T - h_e - \ell \tag{5}$$

The results have simple interpretations since land is the key complementary input to farm labor.

Households with a sufficiently small land endowment cannot obtain their opportunity cost by staying and cultivating land; they choose to surrender their land and work off-farm. Households with a large land endowment have a high marginal product of labor and are thus unaffected by the production constraint. These households optimally allocate all their labor to agriculture while at the same time producing enough output to keep their land. Only households with intermediate levels of land find themselves allocating more labor than would be optimal under unrestricted optimization.

We argue that in the context of Mexican ejidos one can think of most households as belonging to this intermediate range. First, consider that the objective of the original Mexican land redistribution program was to provide land to as many landless peasants as possible. This gave the government an incentive to minimize plot size subject to providing the household a livelihood (the opportunity cost in the model). Secondly, because land transactions were not allowed prior to the Procede program, farms sizes were maintained at an inefficiently small scale.

3.4 Land security and migration

The Procede certificates can be interpreted as allowing farmers to move from the restricted optimization situation to the unrestricted situation. If the minimum labor allocation restriction was binding (regime (ii) with $A_1 \leq A \leq A_0$), farm labor *decreases with the improvement in property rights*:

$$\Delta h_e = h_e^* - \underline{h_e}$$

And migrant labor increases by the opposite amount:

$$\Delta h_m = \underline{h_e} - h_e^* = \left(\frac{\pi_m}{s\gamma}\right)^{\frac{1}{\beta}} A^{\frac{1-\alpha}{\beta}} - \left(\frac{\gamma\beta}{w_m}\right)^{\frac{1}{1-\beta}} A^{\frac{\alpha}{1-\beta}}. \tag{6}$$

In Figure 1, certification is represented by a vertical move from the restricted to the unrestricted on-farm labor schedule. Leisure is unaffected because it is solely determined by the outside wage w_m.

3.5 Heterogeneity in migration response to certification

This simple framework can also be used to obtain comparative statics predictions resulting from household level heterogeneity. Note that, while the level of migration h_m of a household depends on family size (equation 5), this is not the case for the out-migration Δh_m induced by the increase in property rights security (equation 6). This migration response however varies with the strength of informal property rights previously enjoyed, outside wages, farm size, and land productivity. All comparative statics results are obtained by simple differentiation of equation (6).

Degree of security of informal property rights

Heterogeneity in the degree of land insecurity under the old regime can be thought of as heterogeneity in the s parameter. More insecure property rights are reflected as a lower s and a higher required farm activity $\underline{h_e}$. Differentiating (6) with respect to s:

$$\frac{\partial \Delta h_m}{\partial s} = \frac{\partial \underline{h_e}}{\partial s} < 0$$

shows that, *ceteris paribus*, this generates a higher migration response the more insecure property rights are in the old regime.

Off-farm wages

Higher wages commanded higher levels of migration h_m through lower optimal leisure. They also induce a higher migration response to the increased security of property rights:

$$\frac{\partial \Delta h_m}{\partial w_m} = -\frac{\partial h_e^*}{\partial w_m} > 0$$

. Because the unrestricted on-farm labor schedule is lower the more attractive outside opportunities (w_m) are, the regime change leads to larger migration responses from households with better off-farm opportunities.

Farm productivity

Differing farmland quality in the model can be understood as heterogeneity in the productivity parameter γ. Higher land quality reduces the minimum labor necessary to reach the required yield under insecurity and increases the optimal labor that the household should allocate to the farm. Both effects contribute to a reduction in the excess labor imposed by insecure property rights, and hence the migration response to increased security:

$$\frac{\partial \Delta h_m}{\partial \gamma} = \frac{\partial \underline{h_e}}{\partial \gamma} - \frac{\partial h_e^*}{\partial \gamma} < 0$$

This suggests that farms with lower land productivity have more outmigration when moving from a restricted to an unrestricted property rights regime.

Farm size

Differentiation of (6) with respect to A gives:

$$\frac{\partial \Delta h_m}{\partial A} = \frac{\partial \underline{h_e}}{\partial A} - \frac{\partial h_e^*}{\partial A} = \left(\frac{\pi_m}{s\gamma}\right)^{\frac{1}{\beta}} \frac{1-\alpha}{\beta} A^{\frac{1-\alpha-\beta}{\beta}} - \left(\frac{\gamma\beta}{w_m}\right)^{\frac{1}{1-\beta}} \frac{\alpha}{1-\beta} A^{\frac{\alpha+\beta-1}{1-\beta}}$$

This expression can be shown to be negative for land size A greater than a threshold A_2 where the two curves $\underline{h_e}$ and h_e^* have parallel slopes.

$$A_2 = A_1 \left[\frac{(1-\alpha)(1-\beta)}{\alpha\beta} \beta^{\frac{-1}{1-\beta}}\right]^{\frac{\beta(1-\beta)}{\alpha+\beta-1}}$$

The first term in the square brackets is smaller than 1, while the second term is greater than 1, meaning that A_2 can either be greater or smaller than A_1. Hence, the migration induced by relaxing the yield constraint decreases with farm size, except possibly for the smallest farms still operating with $A \in [A_1, A_2]$, if it is the case that $A_1 < A_2$. The case where $A_2 < A_1$ is depicted in Figure 1. In this case the vertical distance between the two curves is clearly decreasing in A. This expression suggests that if there is heterogeneity in land holding size (A) within ejidos, the larger landholders should migrate less in response to the program. This can be thought of as a sorting effect in which the larger farmers are more likely to stay behind while the smaller more marginal farmers migrate.

It is also straightforward to see that this expression implies that the differential induced migration across farm size is sharper in areas with higher land quality:

$$\frac{\partial^2 \Delta h_m}{\partial \gamma \partial A} < 0.$$

This prediction is economically important. It can be interpreted as saying that the migration response of larger landholders in high productivity areas is lower than the migration response of larger land holders in low productivity areas. An equivalent interpretation is that in low productivity areas, the difference in migration response between small and large landholders is not as different as that which arises in high productivity ones.

In summary, we expect increased land security to allow households to allocate the optimal amount of labor to their farm activity instead of the inefficiently high level required by the "use-it or lose-it" restriction. The out-migration response is expected to be larger for households that had weaker property rights under the prior informal regime, that have better outside opportunities, smaller farms, and lower land quality. We also expect that the differential migration response between small and large farms is stronger in areas with better land. These are the results to be taken to the data in sections 5.2 to 5.5.

An important feature of our model is that it does not formally include wealth effects or effects caused by opening of the labor market, both of which could have resulted from the program. Our model instead highlights the importance of a minimum production constraint in preventing households from efficiently allocating labor prior to reform. We defer these potential alternate mechanisms to section 5.7 where they are investigated empirically.

4 Data

In this section we provide a brief overview of the 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 ejido digital maps created during the certification process by INEGI and managed by RAN. GIS ejido boundaries are available for the 26,481 ejidos that completed the program during the period from 1993-2006.[7] The rollout of the program was quite rapid. Nearly half of all ejidos were fully certified by 1997 while all but a small subset of ejidos had completed the program by 2006. The curve in Figure 2 gives the share of these ejidos that had completed the program by each year from 1993-2006. Figure 2 also shows

[7] These data also include 246 ejidos that were in the process of certification but had not yet completed the program during 2007. They do not include the remaining 2500 ejidos that were left to a special program after Procede closed in 2006.

the dates of the other datasets used: the Progresa surveys (ENCEL), the population censuses, the ejido censuses, and the land use maps. Figure 3 shows the rollout of Procede at the national level, helping visualize the extensiveness and national scope of the program.

We use the 1998-2000 Encuesta Evaluacion de los Hogares (ENCEL) surveys administered in the evaluation of the anti-poverty program Progresa to study individual migration behavior.[8] The ENCEL data consist of a panel of approximately 25,000 households from 506 poor localities that qualified for the program, 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 in the GIS database. This process matched 200 localities to 195 different ejidos. Of these ejidos, 68 were certified in 1993-1996, 51 in 1997-1999, and 76 after 1999. Returning to Figure 3, it is the households in the ejidos certified during the period from 1997-1999 (upper-right to lower-left panels) that provide our identification of the effect of certification on migration. Our final data consists of an unbalanced panel of 7,577 households from ejidos that were certified after 1996.[9] 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 2 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 17,328 localities.[10] These data cover all states of Mexico and therefore have broader geographic coverage than the panel of Progresa households. Figure 4 gives the distribution of population growth from 1990 to 2000 in these localities. Approximately 62% of the localities in ejidos experienced a decline in population during the period from 1990-2000.

The fourth dataset we use is the Ejido Census (Censo Ejidal) from INEGI that was administered

[8]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.

[9]The panel is unbalanced due to attrition as well as addition of a small number of households to the sample in 1999 and 2000. Our migration result is robust to estimation with a fully balanced panel of households.

[10]All regressions at the community level exclude localities that had population of 20 or less individuals in 1990. Small localities often disappear or are regrouped over time and we therefore drop them from the analysis.

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 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 ejido GIS 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 during 1993, 2002, and 2007 and a series of field verifications by INEGI. The digital ejido boundaries were overlaid on the land use maps 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 certified 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

Before discussing regressions results, it is useful to consider some simple evidence suggesting over-allocation of labor to agriculture in ejidos. One implication of our model is that inefficiently large amounts of labor should be allocated to agriculture in ejidos in order to secure continued ownership of land. Summary data from the 1991 agricultural census indicate that the number of farm operators per hectare of land in the Mexican private sector (non-ejido) was 0.041. The number of operators per hectare of land in the ejido sector was 0.052. This simple comparison is consistent with over-allocation of effort to agriculture in order to maintain property ownership.

5.1 The impact of land certification on migration

We establish our basic result that rural land certification 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 that left the ejido since the onset of our observations. The main estimating equation is:

$$y_{ijt} = \delta Certif_{jt} + \gamma_j + \alpha_t + x_{ijt}\beta + \varepsilon_{ijt}, \tag{7}$$

where y_{ijt} is an indicator for whether household i in ejido j has a permanent migrant by year t,[11] $Certif_{jt}$ is an indicator for whether 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 vector of household level covariates, and ε_{ijt} is a random error term. Standard errors are clustered at the ejido level during estimation. This is a standard fixed effects regression where identification is coming from changes in migration behavior correlated to changes in certification status. 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 uncorrelated with the distribution of certificates. We provide support for the validity of this identification assumption in the next section, focusing first on the results.

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. This happened against a background of intense migration. During the same period, the natural trend (year fixed effects in the regression) shows that 5% of the households acquired a new migrant. Hence Procede is estimated to have contributed to an additional .015/.05=30% in the number of households with migrants during these 3 years.[12]

The second column in Table 1 shows that the estimated program effect is almost identical when household level covariates are included in the regression. This minimal change is consistent with the fact that certificates were distributed to all ejidatario households in the ejido. The third column shows that the estimated coefficient is robust to replacing ejido fixed effects by household fixed effects. A key concern for our identification strategy is the possibility of differential time trends that would be correlated with the timing of the certification. In columns (4)-(6) we show that the results are robust to more flexibly controlling for specific time trends. In column (4) we allow the time effects to be specific by state. Column (5) includes interaction terms between each

[11] Once a household has had a migrant leave, its value of y remains at one for the remainder of the sample period.
[12] Since all households are uncertified in our baseline year of 1997, the certification effect is estimated for the period from 1998-2000.

time effect and the household-level covariates. In column (6) we include interactions between time effects and some key ejido-level characteristics that are correlated with the date of certification. Our main estimate is robust to the additional controls for specific time trends. Hence, the behavior of families in the Progresa dataset firmly points to land certificates increasing the probability that a household member migrates.

Next, we study migration behavior at the community level using the matched 1990 and 2000 population censuses. The community level analysis captures both migration of individuals and entire families. Three key characteristics of this alternate dataset are its inclusion of localities of all sizes and levels of income, its geographical coverage (nationwide), and longer time span (up to 7 years with certificate). 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 locality population over time in a standard two-period fixed effects regression:

$$Pop_{jt} = \gamma_j + \beta I(t = 2000) + \delta I(Certified\ by\ 2000_j = 1) I(t = 2000) + \varepsilon_{jt}. \qquad (8)$$

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

$$Pop_{jt} = \gamma_j + \beta I(t = 2000) + (\delta_0 + \delta_1 Years\ Certified_j) I(Certified\ by\ 2000_j = 1) I(t = 2000) + \varepsilon_{jt}. \qquad (9)$$

We finally partition the ejidos certified between the two censuses into early certified and late certified groups and estimate separate effects for the two groups:

$$Pop_{jt} = \gamma_j + \beta I(t = 2000) + \delta_1 I(Certified\ before\ 1997_j = 1) I(t = 2000) + \delta_2 I(Certified\ from\ 1997 - 1999_j = 1) I(t = 2000) + \varepsilon_{jt}. \qquad (10)$$

The dependent variable is the total population (or logarithm) of locality j in year t (1990 or 2000). The first specification (8) 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 (9) takes into account the number of years since certification, allowing the migration response to take effect over several years in a linear way. The third specification (10) estimates a separate certification effect for localities in ejidos certified in 1993-1996 (δ_1) and localities in ejidos certified in 1997-1999 (δ_2).

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 9.6 persons or 20% of their population between 1990 and 2000 (the time effect). The coefficients on the interaction term in the second row indicates that Procede was associated with an *additional reduction* in population of approximately 3-4 individuals, in a setting where the average locality has 99 individuals (column (1)), or 4% of its population (column (2)). While results are less statistically precise, column (3) suggests that the loss of population is progressive over time, with a decline of approximately 0.54% of the population per year after Procede certification. In column (4) we estimate separate effects for early certified ejidos (before 1997) and late certified ejidos (1997-1999). The estimated effect of certification is a 5.9% decrease in population for early certified ejidos and a 2% decrease for later certified ejidos. The difference between early and later certified ejidos is statistically significant. The large difference is consistent with certification leading to initial migration and further migration after migrant networks are established in destination communities, as in Munshi (2003) who shows that migration networks take approximately 3-4 years to develop. As a specification check we use 12,455 localities with available population in 1980 to estimate a version of (8) for the period 1980-1990. The estimate in column (5) indicates that the difference in population change in the 1980-1990 decade between early and later certified localities was very small and not significant. This similarity in pre-program population trends suggests our estimate is not being driven by pre-1990 differences in population change between early program and later program areas.

Ubiquity of the emigration effect across the whole distribution of change in population is illustrated in Figure 5. The solid black line represents the empirical distribution function for the change in population from 1990 to 2000 for localities in ejidos that were certified between the two censuses. The dashed line represents localities in ejidos certified in 2000 or later.[13] The distribution for localities in ejidos not certified by 2000 stochastically dominates that for certified 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.

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

How does this estimated effect of Procede on the locality population compare to what was revealed in the selected Progresa communities? The Progresa data document emigration from 1997 to 2000, in localities that were certified from 1997 onwards. Comparison can thus be drawn with column (4) of Table 2. It shows a baseline migration of 20.7% of the population over 10 years, which corresponds to an average annual rate of 2.3% (=$0.793^{0.1}$). The certification effect for those ejidos certified in 1997-99 is an additional effect of 1.96% over these 3 years, or an average annual effect of 0.7%. Hence the Procede effect in those ejidos is associated with an increase of the annual loss of population of 29% (=0.7/2.3), an order of magnitude similar to the 30% relative increase found in the Progresa analysis. So while we looked at different measures of migration in the two datasets (households sending off one permanent migrant in the Progresa dataset and population change in the locality dataset), we find that Procede has had the same relative effect of increasing migration by an additional approximate 30% in both types of communities.

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 in 2007. Furthermore, because the migration question was not asked in the first round, we can only perform a cross sectional regression. Our dependent variable is the response to a question from the 2007 census asking if the majority of young people leave the ejido. We estimate a cross-sectional regression of the form:

$$Y_{js} = \alpha + \gamma_s + \delta \, \mathit{Years\ Certified}_{js} + x_{js}\beta + \varepsilon_{js}. \tag{11}$$

where γ_s are state fixed effects and x_{js} is a vector of ejido level covariates in 1991 (before Procede). The dependent variable Y_{js} 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 population 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 previous two tables.

Results are reported in Table 3. Column (1) shows a positive association between the years since certification and the probability that the majority of young people migrate 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 certified 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 30%, the locality population declined by 4%, 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 migration effects to the 1.7 million population of the localities matched to ejidos (17,328 localities with average population of 99.1 as reported in Table 2 column(1)) suggests that Procede would have been responsible for an outmigration of about 4% of them or almost 70,000 people. This should be compared against a natural trend of a loss of 20.7% or 350,000 people in these communities in 10 years.

These results should not be interpreted as suggesting a reduction in welfare. On the contrary, as the model suggests, we interpret this as evidence that inefficient amounts of labor had been allocated to the land under the regime with more insecure property rights. The program merely allowed households to adjust from an inefficient equilibrium with too much farm labor to an efficient equilibrium with less farm labor.

5.2 Heterogeneity in pre-reform property rights security

The model predicts that the migration response to land certification should be larger when pre-reform property rights are weaker ($\frac{\partial \Delta h_m}{\partial s} < 0$). As a measure of *between ejido* security, we use a question from the 1991 ejido census on the presence of boundary problems within the ejido. Column (1) of Table 4 shows that the point estimate of the migration effect of certification is more than double for households in ejidos where boundary problems were present. A concern with this specification is that migration could increase over time in ejidos with boundary problems independent of certification. We control for differential time effects in column (2). The difference between ejidos with and without boundary issues becomes larger with the addition of specific time effects. The effect of certification on the probability of having a migrant household member increases from 0.008 for households in ejidos without boundary problems to 0.036 for households in ejidos with problems. This difference is significant at the 10% level.

Next, as a measure of *within ejido* insecurity, we use an indicator for a female headed household. Work by anthropologists indicates that, prior to Procede, female ejidatarias held low status inside the ejido (Stephen, 1996; Deere and Léon, 2001; Hamilton, 2002). For example 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." 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 prompted the use of a female headed household dummy as a proxy for weaker ex-ante property rights. We must however interpret our result with caution since female headed households are almost certainly different for reasons other than s in our model.

Columns (3) and (4) show that indeed the effect of certification on migration of household members is significantly larger for female headed households. 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 (marginal effect of Procede of 0.065 compared to the mean value of 0.056). These effects contrast with the smaller impact for male-headed households.

The results are consistent with improvements in property rights brought about by land certificates having much larger effects for households with weaker rights prior to certification. In terms of the model, we interpret this as individuals with weaker property rights (lower s) being more constrained prior to the program and thus having to dedicate more labor to the farm to maintain their land. Hence, receipt of land certificates resulted in a larger migration response for these households.

5.3 Heterogeneity in off-farm wages

We derive an empirical measure of off-farm wage opportunities by using the 1994 Encuesta Nacional de Ingresos y Gastos de los Hogares (ENIGH) household survey to estimate off-farm wages as a function of gender, years of education, the interaction between gender and years of education, a quadratic function of age, and a state fixed effect. We limit this estimation to wage earners that were 18-50 years old since this population is more representative of the population of potential migrants. We then used the wage equation to predict wages for each adult in the set of Progresa households matched to ejidos. The maximum predicted off-farm wage amongst adults 18-50 was taken as the household's off-farm wage opportunity.[14] In columns (5) and (6) of Table 4 we estimate a separate certification effect for households above and below median values of off-farm wage opportunity. The difference in migration response to certification between households with high and low wage opportunities is statistically significant at the 10% level. Using the results from column (6), the estimated increase in the certification effect for male headed households that have above median off-farm wage opportunities is 0.026 and is statistically significant at the 10% level. These results are consistent with the theoretical prediction that the migration response should be larger for households that have higher wage opportunities outside of agriculture ($\frac{\partial \Delta h_m}{\partial w_m} > 0$).

5.4 Heterogeneity in farm productivity

The theory predicts that certification leads to a smaller migration response in places with higher land productivity ($\frac{\partial \Delta h_m}{\partial \gamma} < 0$). A common measure of land productivity in Mexico is rainfed corn yield. This measure has the advantage of its geographical coverage, as corn is the staple food grown all over the country. However it is only systematically available at the municipality level and since 2002 from SAGARPA (Ministry of Agriculture). We use the average corn yield over the period 2002-2008 as the measure of land productivity, and partition agricultural land as high or low productivity at the median yield of 1.29 tons/ha. Columns (1) and (2) of Table 5 show that, as predicted, the migration response to certification is weaker (and almost null) in ejidos where land is more productive.

[14]Predicted wage was set to 0 if the household did not have any individuals in the 18-50 years old range.

5.5 Certification, sorting, and migration

The final prediction derived in the model is that large farms in productive regions are expected to respond less to certification with labor re-allocation ($\frac{\partial^2 \Delta h_m}{\partial \gamma \partial A} < 0$). We test for this by splitting the sample into low and high productivity areas (using the maize yield variable defined above) and creating an indicator variable which is equal to one if a farmer has more land than the median farmer in his ejido.[15]

The results in row (3) are striking. In low productivity areas, larger landholders are not significantly less likely to migrate than land poor farmers. The coefficient is negative but insignificant. In contrast, in high productivity areas, larger landholders increase their migration *significantly less* than land poor farmers. In fact, the overall effect of certification for land-rich households in high productivity areas is not statistically different from zero. In sum, these results are consistent with the prediction of the model that households are sorted according to their landholdings: larger, more productive farmers stay on the farm, whereas smaller more marginal farmers respond to improved security of tenure by having more members migrate.

5.6 Certification, land use, and migration

The model we presented considered an autonomous household deciding how to allocate labor on and off the farm. According to the model, the security of tenure provided by certification made households allocate less labor to the farm. A logical byproduct of this phenomenon is that less agricultural labor should be reflected in more land being left fallow. In reality, Procede also made land rental transactions legal, and in doing so reduced uncertainties in transactions that could only take place illegally before. We therefore expect the rental market to have intensified. There are two reasons why land reallocation is desirable: First, the idea that individually allocated land was inefficiently small suggests there are potential gains from consolidating landholdings. Second, if some farmers are more productive than others, certification can lead to gains from trade.

While we do not observe land transactions (rentals or sales),[16] we can determine if the certifi-

[15]Families are ranked in each ejido in the Progresa dataset according to their landholdings into those with more and less than the median land per adult household member in the ejido in 1997.

[16]Deininger and Bresciani (2001) report observing an increase in land rental in 1997 compared to 1994. This is however difficult to directly verify, as an increase in declared rentals could be partly due to a change in the transparency of these transactions.

cation program lead to changes in the amount of cultivated land. If security of tenure meant that families could now leave the land fallow without risk of loss, cultivated land would decrease. Alternatively, if land was rented out or sold to other community members by households with migrants, we should observe no changes in cultivated land. Finally, if the certification program provided better incentives to invest in agriculture, we would observe increases in cultivated acreage.

For this exercise, 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. We estimate the reduced form impact of certification on the logarithm of cultivated area in a standard fixed effects framework:

$$\log(Agland_{jt}) = \gamma_j + \alpha_t + \delta Certified_{jt} + \varepsilon_{jt}, \quad (12)$$

where j indexes ejidos and t refers to the year of the land use observation. 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. This suggests that migration driven by improved tenure security did not lead to a proportional fall in area dedicated to agriculture. If marginal farmers were fallowing land in order to migrate, then we should see a decrease in agricultural land after certification. The absence of this decrease suggests that unused land was being cultivated by larger farmers that did not send additional migrants.

In columns (2) and (3) we show that the overall land use response actually masks some interesting heterogenous effects by land quality. Column (2) shows that cultivated land actually increased with certification in agriculturally favorable areas but decreased in poorer areas. In column (3), we further control for differential time trends in high and low yield areas. The estimated coefficient 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 high agricultural productivity areas. The point estimate ranges from 1.3 to 1.6%, and the difference between favorable and non-favorable areas is significant.[17]

[17] As a robustness check on the resolution of the Landsat images, we ran all the regressions in Table 6 after dropping the smallest 5% of ejidos. The coefficients change only minimally and statistical significance is unaffected (results not reported).

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.[18] 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 that was identified in Table 2 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 6. 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 interaction between certification and year 2000. Hence, localities with the most pronounced declines in agricultural land ($rank=0$) experienced a decline in population of 9.2% in response to certification, while localities in ejidos with the largest increase in agricultural land saw no effect of certification on population.

Figure 7 depicts the estimated marginal effect of certification, (i.e. $\widehat{\delta} = -0.0924 + 0.0876 * rank$), 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 statistically negative in the 65% of localities where agricultural land decreased or increased only slightly from 1993-2007.

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,

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

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 consistent with this interpretation.

5.7 Alternative channels from certification to migration

Our model focused on the effect that relaxing the land use constraint (minimum production level, without any use of external labor) may have had on freeing members of ejidatario households to migrate. Acquisition of property rights however also confers a major increase in wealth and potential liquidity through the sale or rental of land or through the increased availability of credit. Migration is costly and liquidity constraints may be binding for many poor households that would otherwise choose to migrate. In the context of Mexico, McKenzie and Rapoport (2007) shows that migration to the U.S. is strongly related to wealth.

We thus explored the possibility that liquidity effects arising from certification allowed for increased outmigration. In essence, if land certification increases liquidity, increased wealth could have been used to cover fixed costs of migration. If this were the case, then we should expect to see larger effects of certification in villages that were control villages for the experimental evaluation of Progresa. Villages that were not receiving Progresa payments would have faced greater liquidity constraints and therefore would be more likely to respond to certification by increasing migration. The results in Table 8 suggest that the opposite is true. In Column 1 we estimate separate migration effects of certification for Progresa treatment and control villages. The certification effect in treatment villages is .021 and that for control villages is .006. The difference between control and treatment villages is not statistically significant. Further, we can rule out that the migration induced by certification was significantly greater in Progresa control villages. These additional results suggest that liquidity effects are not explaining the observed migration effect.

Another feature of the reform is that hiring labor become legal after the program. The creation of a functioning market for agricultural labor could then allow households to increase migration while at the same time hiring labor to maintain constant productivity. If the creation of a rural labor market is driving our results, we would expect the correlation between household size and the amount of land cultivated to decrease significantly after the completion of Procede. The basic intuition is that a large labor endowment was necessary to cultivate a large amount of land prior to the program. If the program had a significant impact on the labor market, then this correlation should decrease after completion of Procede. This test is related to the absence of a rural labor market causing non-separation between production and consumption (Benjamin, 1992). We estimate,

$$\begin{aligned} Hectares_{ijt} =& \beta_0 Certif_{jt} + \beta_1 Adults_{ijt} + \beta_2 Adults_{ijt} * Certif_{jt} + \gamma_j + \mu_t \\ &+ \theta_t * Adults_{ijt} + x_{ijt}\alpha + \varepsilon_{ijt}, \end{aligned} \tag{13}$$

where $Hectares_{ijt}$ is land cultivation and $Adults_{ij}$ is the time-varying number of adults in the household. A negative and significant estimate of β_2 would be expected if labor market effects were important. The result in Column 4 of Table 8 shows that the correlation between size and cultivation does not decrease significantly after program completion. The 95% confidence interval on the term $Adults_{ijt} * Certif_{jt}$ implies that we can rule out that any more than approximately 12% of the correlation between size and cultivation was eliminated after Procede. Our results therefore appear to be most consistent with a model where cultivation is used as a means of maintaining ownership of land.

6 Internal validity checks

We present several tests that support the validity of the identifying assumptions of 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 program 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 standard regression of *pre-program* changes in ejido level migration rates on indicators for the year Procede was completed:

$$\Delta y_{jt} = \gamma + \alpha_t + \sum_{k \geq t} \delta_k I(Procede\ Year_j = k) + \varepsilon_{jt} \quad \forall t \leq Procede\ Year_j. \tag{14}$$

The dependent variable Δy_{jt} is the change in the average level of the migrant 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 data covers the years 1997 to 2000, only three such variables are necessary for the ejidos certified in 1999, 2000, or after 2000.[19] *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 9. In the first column, we consider all the ejidos that completed certification during or after the year 1998 (and hence did not appear as certified in the data until 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 (2), 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 period fixed effects and indicators for the year Procede was completed. And similarly with three pre-treatment observations for the 76 ejidos certified in 2000 or after, in column (3). The p-values for joint significance of the Procede year variables are 0.19, 0.49 and 0.74. 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,

$$y_{jt} = \gamma_j + \alpha_t + \beta_0 \cdot Year\ of_{jt} + \beta_1 \cdot Year\ before_{jt} + \beta_2 \cdot 2\ Years\ before_{jt} + \varepsilon_{jt}, \tag{15}$$

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

[19] The base group is composed of 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.

migration levels were significantly different than average in the ejido during the years directly before the program. The fourth column of Table 9 gives the results of estimating (15). 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.

A similar concern with our identification strategy is that anticipation of being certified in the future would lead to a decrease in migration in uncertified ejidos. Our observed increase in migration would then reflect an anticipation effect and not a true migration effect. The results in column (4) of Table 9 are not consistent with a large decrease in migration during the years immediately prior to the program.

Another potential issue of concern is attrition of households from the ENCEL survey. 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.[20] In Table 10 we run the basic regression used to identify the role of Procede on migration, equation (7), on attrition. The coefficient of the certified variable is both insignificant and very small. There is therefore no evidence that the migration effect we estimate 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. We showed that if property rights were tied to actual land use in the previous regime, these policies can induce increased outmigration from agricultural communities. We provided 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 certifi-

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

cates along both the intensive and extensive margins. Families that obtained certificates are 30% more likely to have a migrant household member and the overall locality population falls by 4%. The estimated effect increases over time.

We also documented heterogeneity in migration response according to the ex-ante level of property rights insecurity and the level of off-farm opportunities. We also found that the migration response is larger in lower land quality environments.

There is also evidence of sorting within the community: larger farmers stay, whereas land-poor farmers leave, and this effect is starker in high productivity areas. This prompts the question of whether total acreage under cultivation decreased with the program. We find that, on average, cultivated land was not reduced because of the program, which is consistent with gains in agricultural labor productivity. Additionally, we showed that in high productivity areas, 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. These results are most consistent with a model where the key constraint imposed by insecure property rights is the requirement of continued presence. Other empirical evidence is not consistent with either wealth effects or better functioning labor markets being the mechanism explaining the increase in migration.

One key implication of our results is that studies on the agricultural productivity effects of land titling programs need to pay careful attention to changes in the study population over time. Our results indicate that more marginal and less productive farmers are more likely to migrate after obtaining more secure ownership of land. This change in the composition of the population has important implications for studying productivity effects. Estimates of the effects of titling on productivity could be *biased upwards* if this migration/attrition is not properly addressed.

An important policy implication of the results is that the benefits of formal land certification in rural areas may be more complex than simple increases in agricultural productivity. Certification often removes a key distortion that resulted in an inefficient allocation of household labor between uses. Removal of this distortion allows households to more efficiently allocate labor between agricultural and off-farm activities.

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.[21] 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.

[21] 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 locaelity 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%.[22] This round generated an additional 1,787 matches.

[22] 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.[23] 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.[24] 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.

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[23]It is common for ejido names to be the same as locality names in Mexico.

[24]This value was chosen since it was the 10th percentile in the list of candidate matches.

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Tables

Table 1: Effect of Procede on household migration behavior

	Progresa Households Matched to Ejidos					
	(1)	(2)	(3)	(4)	(5)	(6)
	Has Migrant	Has Migrant	Has Migrant	Has Migrant	Has Migrant	Has Migrant
Certified	0.0149**	0.0158**	0.0153**	0.0172***	0.0157**	0.0153***
	(0.0061)	(0.0064)	(0.0062)	(0.0059)	(0.0063)	(0.0058)
HH is Landholder		0.0136***			0.0048	
		(0.0044)			(0.0053)	
Number Males 17-30 in HH		0.0195***			0.0088**	
		(0.0046)			(0.0037)	
HH Head is Female		0.0127			0.0092	
		(0.0101)			(0.0082)	
Age of HH Head		0.0009***			0.0004***	
		(0.0002)			(0.0001)	
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Ejido Fixed Effects	Yes	Yes	No	Yes	Yes	Yes
HH Fixed Effects	No	No	Yes	No	No	No
State x Time Effects	No	No	No	Yes	No	No
HH Characteristics x Time Effects	No	No	No	No	Yes	No
Ejido Characteristics x Time Effects	No	No	No	No	No	Yes
Mean of Dep Variable	0.053	0.056	0.053	0.053	0.056	0.053
Number of Observations	27189	24533	27189	27189	24533	27189
R squared	0.047	0.058	0.043	0.048	0.059	0.048

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. Ejido characteristics in column 6 are number of ejidatarios, number of posesionarios + avecindados, the total size of the ejido, longitude, and latitude.

Table 2: Effect of Procede on locality-level population

	Census Localities Matched to Ejidos				
	(1)	(2)	(3)	(4)	(5)
	Population	ln(Population)	ln(Population)	ln(Population)	ln(Population),1980-1990
Year=2000	-9.6309***	-0.2069***	-0.2069***	-0.2069***	
	(1.0014)	(0.0105)	(0.0105)	(0.0105)	
Certified 1993-1999*Year=2000	-3.6893***	-0.0404***	-0.0206		
	(1.1485)	(0.0128)	(0.0195)		
Years Certified in 2000*Certified 1993-1999*Year=2000			-0.0054		
			(0.0039)		
Certified Before 1997*Year=2000				-0.0592***	
				(0.0144)	
Certified 1997-1999*Year=2000				-0.0196	
				(0.0151)	
Year=1990					-0.2094***
					(0.0125)
Certified 1993-1999*Year=1990					-0.0082
					(0.0148)
Ejido Fixed Effects	Yes	Yes	Yes	Yes	Yes
Mean of Dep Variable	99.111	4.271	4.271	4.271	4.416
Number of Observations	34656	34656	34656	34656	24910
R squared	0.014	0.035	0.036	0.036	0.033

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. Regressions in columns 1-4 based on 17,328 localities that were matched to ejidos, had population data in both the 1990 and 2000 censuses, and had a population of more than 20 individuals in 1990. Regression in column 5 is based on 12,455 localities with available population data in 1980 and with a population larger than 20 in 1980.

Table 3: Effect of Procede on ejido-level migration of young people

	Matched Ejidos in 1991 and 2007 Ejido Census			
	(1)	(2)	(3)	(4)
	Migrate	Migrate	Migrate US	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 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. 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	(6) Has Migrant
Certified	0.0138	0.0081	0.0102	0.0096	-0.0028	-0.0041
	(0.0088)	(0.0086)	(0.0063)	(0.0064)	(0.0085)	(0.0093)
Certified*Ejido Had Boundary Problems in 1991	0.0164	0.0278*				
	(0.0142)	(0.0145)				
Certified*HH Head is Female			0.0596**	0.0648**	0.0649**	0.0702**
			(0.0247)	(0.0277)	(0.0252)	(0.0282)
Certified*Above Median Predicted Wage					0.0247*	0.0262*
					(0.0139)	(0.0155)
Above Median Predicted Wage					0.0015	0.0010
					(0.0056)	(0.0056)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Ejido Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects*HH Head is Female	No	No	No	Yes	No	Yes
Time Effects*Ejido Had Boundary Problems in 1991	No	Yes	No	No	No	No
Time Effects*Above Median Predicted Wage	No	No	No	No	No	Yes
Mean of Dep Variable	0.057	0.057	0.056	0.056	0.056	0.056
Number of Observations	21090	21090	24533	24533	24513	24513
R squared	0.060	0.060	0.059	0.059	0.059	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. All regressions include landholder indicator, age of household head, indicator for female household head, and number of males between 17 and 30 as controls. *Ejido had boundary problems* is an indicator variable for response of yes to this question during the 1991 ejido survey. *Above Median Predicted Wage* = 1 if the household's predicted maximum off-farm wage is above the median in the sample.

Table 5: Heterogeneity in certification effect according to baseline land

	All Municipalities		High Yield Municipalities		Low Yield Municipalities	
	(1) Has Migrant	(2) Has Migrant	(3) Has Migrant	(4) Has Migrant	(5) Has Migrant	(6) Has Migrant
Certified	0.0298***	0.0312***	0.0159*	0.0201**	0.0351***	0.0370***
	(0.0097)	(0.0101)	(0.0090)	(0.0099)	(0.0129)	(0.0127)
Certified*High Maize Yield Municipality	-0.0232*	-0.0256**				
	(0.0124)	(0.0126)				
Certified * Land per Adult > Median in Ejido (1997)			-0.0240*	-0.0339**	-0.0095	-0.0145
			(0.0122)	(0.0157)	(0.0157)	(0.0164)
Land per Adult > Median in Ejido (1997)	0.0061	0.0061	0.0134*	0.0035	0.0038	-0.0007
	(0.0051)	(0.0051)	(0.0073)	(0.0057)	(0.0058)	(0.0045)
Ejido Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects*Land per Adult > Median in Ejido	No	No	No	Yes	No	Yes
Time Effects*High Maize Yield Municipality	No	Yes	No	No	No	No
Mean of Dep Variable	0.056	0.056	0.057	0.057	0.054	0.054
Number of Observations	24372	24372	14533	14533	9839	9839
R squared	0.058	0.058	0.052	0.052	0.068	0.068

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. All regressions are linear probability models. Certified indicator = 1 if ejido was certified at the start of the year. All regressions include age of household head, indicator for female household head, and number of males between 17 and 30 as controls. Columns 1 and 2 are for all matched ejidos in the Progresa sample. Columns 3 and 4 are for ejidos in municipalities with average maize yields above 1.293 tons/hectare. Columns 5 and 6 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) Log(Area Ag.)	(2) Log(Area Ag.)	(3) 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 average maize yield in the municipality of the ejido is larger than 1.293 tons/ha.

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	-0.2285***	-0.1936***	-0.1765***
	(0.0143)	(0.0195)	(0.0239)
Certified 1993-1999*Year=2000	-0.0230	-0.0760***	-0.0924***
	(0.0183)	(0.0232)	(0.0292)
Rank of Ag Change * Year=2000			-0.0705*
			(0.0368)
Rank of Ag Change * Certified 1993-1999 * Year=2000			0.0876*
			(0.0461)
Ejido Fixed Effects	Yes	Yes	Yes
Mean of Dep Variable	4.240	4.324	4.278
Number of Observations	15200	12420	27624
R squared	0.035	0.041	0.038

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. Localities located in ejidos with no agricultural land during either 1993 or 2007 are excluded from the regressions, thus explaining the difference in observations from Table 2. 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: Alternative explanations of migration effect of land certification

	(1) Migration	(2) Hectares	(3) Hectares	(4) Hectares	(5) Herfindahl
Certified	0.0056	0.0333	0.0185	-0.1135	0.0268
	(0.0086)	(0.1732)	(0.1369)	(0.1670)	(0.0320)
Certified*Progresa locality	0.0153				
	(0.0123)				
Adults in HH in 1997		0.4335***			
		(0.0395)			
Certified*Adults in HH in 1997		-0.0210			
		(0.0480)			
Adult males in HH in 1997			0.6121***		
			(0.0569)		
Certified*Adult males in HH in 1997			-0.0328		
			(0.0643)		
Adults in HH				0.4314***	
				(0.0393)	
Certified*Adults in HH				0.0296	
				(0.0414)	
HH Head is Female		-0.4474***	-0.2801***	-0.4606***	
		(0.0745)	(0.0777)	(0.0741)	
Age of HH Head		0.0267***	0.0278***	0.0268***	
		(0.0027)	(0.0027)	(0.0027)	
Ejido Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes
Time Effects*Progresa Locality	Yes	No	No	No	No
Time Effects*Adults in HH in 1997	No	Yes	No	No	No
Time Effects*Adult males in HH in 1997	No	No	Yes	No	No
Time Effects*Adults in HH	No	No	No	Yes	No
Mean of Dep Variable	0.054	2.121	2.121	2.121	0.116
Number of Observations	26690	24219	24219	24211	506
R squared	0.047	0.286	0.283	0.288	0.547

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. Column 2 and 3 drop the top 1% of observations with hectares cultivated of 25 or more.

Table 9: Relationship between Procede and pre-program migration

	Progresa Households Matched to Ejidos, Pre-Program Period			
	(1)	(2)	(3)	(4)
	Δ Migration,97-98	Δ Migration,97-99	Δ Migration,97-00	Migration,97-00
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 10: Regressions of attrition on certification status and household covariates

	(1) Attrition
Certified	-0.003
	(0.025)
HH is Landholder	-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 had a certificate 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

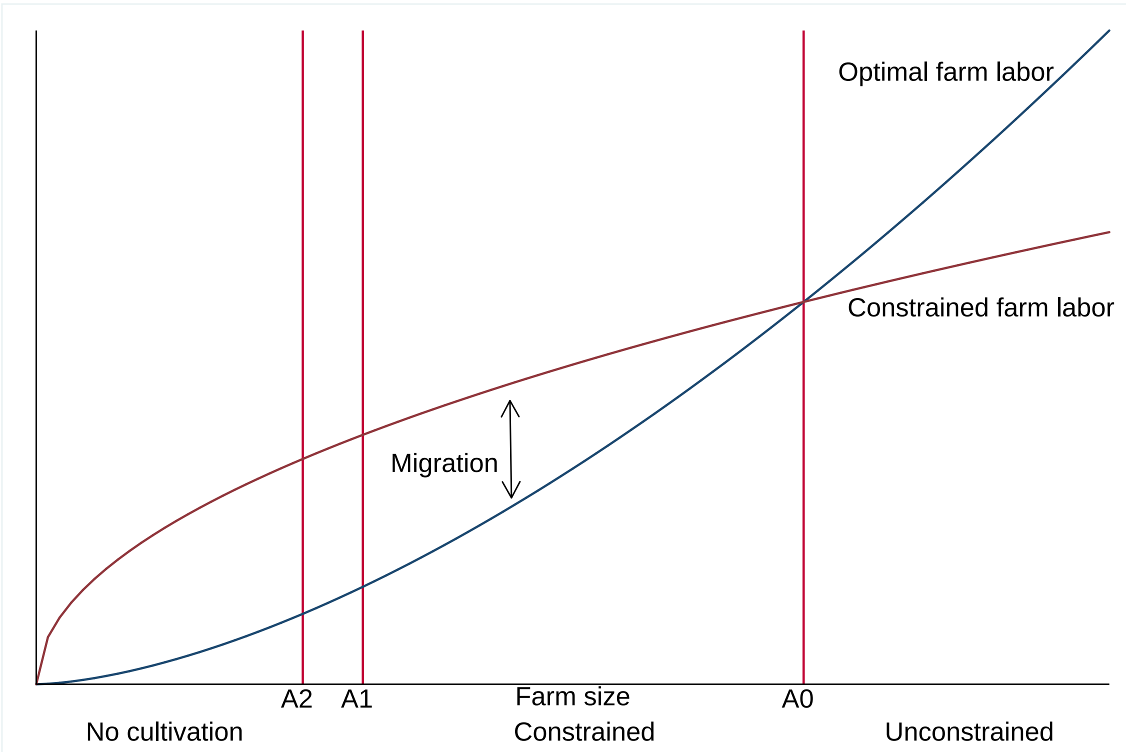

Figure 1: Labor allocation to farm production

Notes: Figure shows theoretically optimal agricultural labor use as a function of farm size. Optimal farm labor is labor use when property rights are fully secure. Constrained farm labor is labor use when insecure property rights create a minimum production constraint. See Section 3 for other details on theoretical model.

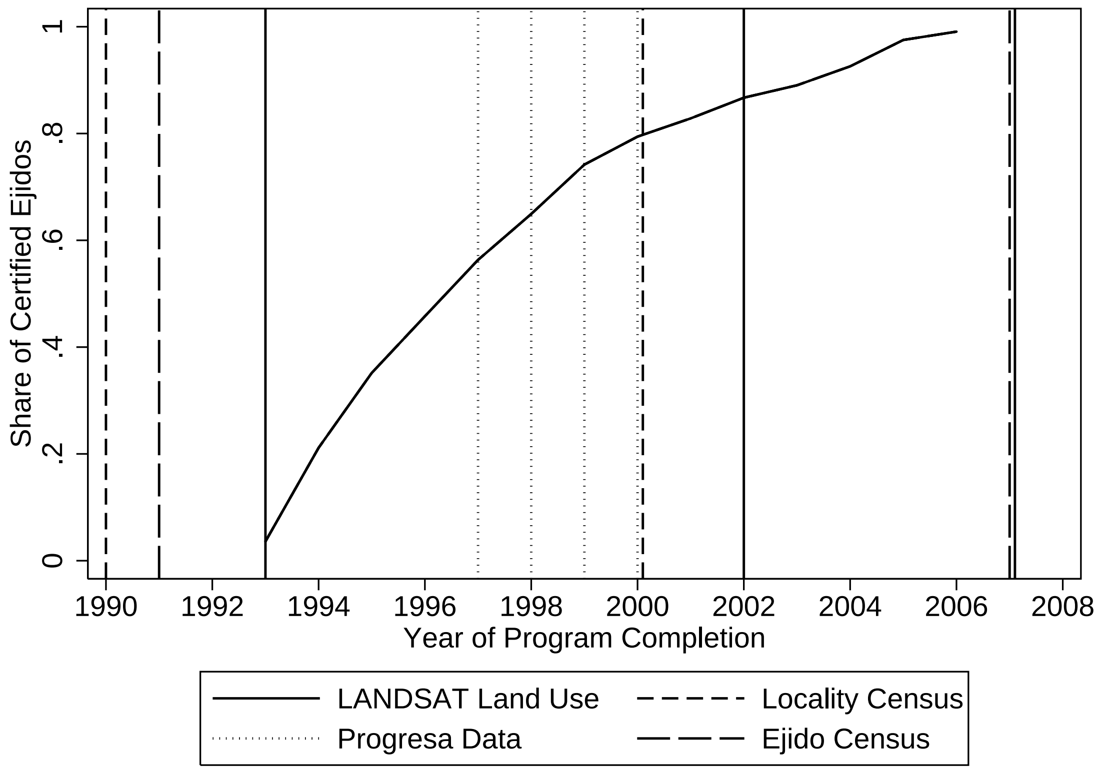

Figure 2: Correspondence between data and rollout of Procede

Notes: Figure shows cumulative share of ejidos completed over time. Vertical lines represent observations for each of the datasets used in the analysis. 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.

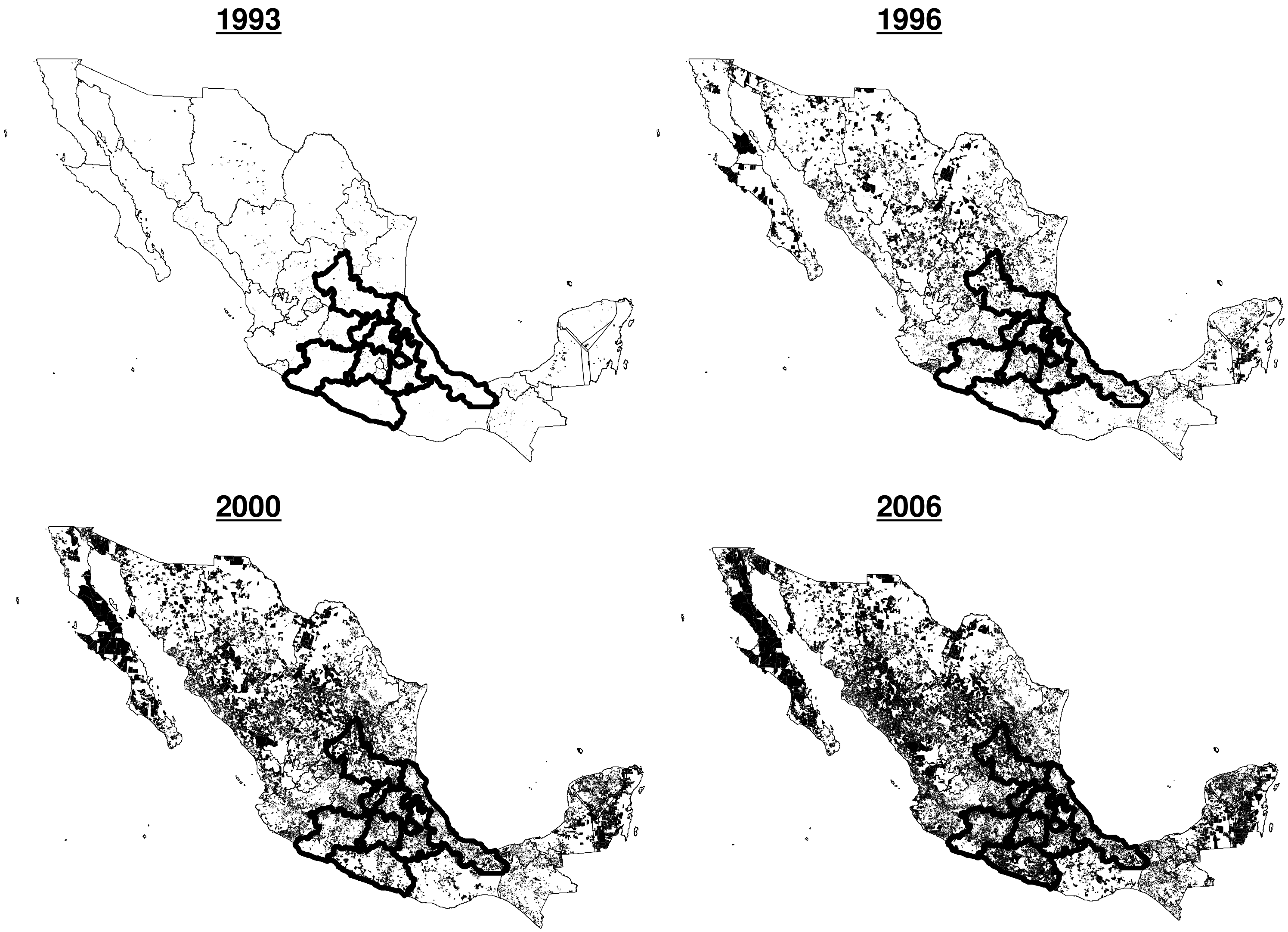

Figure 3: Rollout of Procede across time and space

Notes: Shaded ejidos are those that completed the Procede program during or before the listed year. States with bold outlines are 7 Progresa states for which we have migration outcomes (Guerrero, Hidalgo, Michoacan, Puebla, Queretaro, San Luis Potosi, and Veracruz).

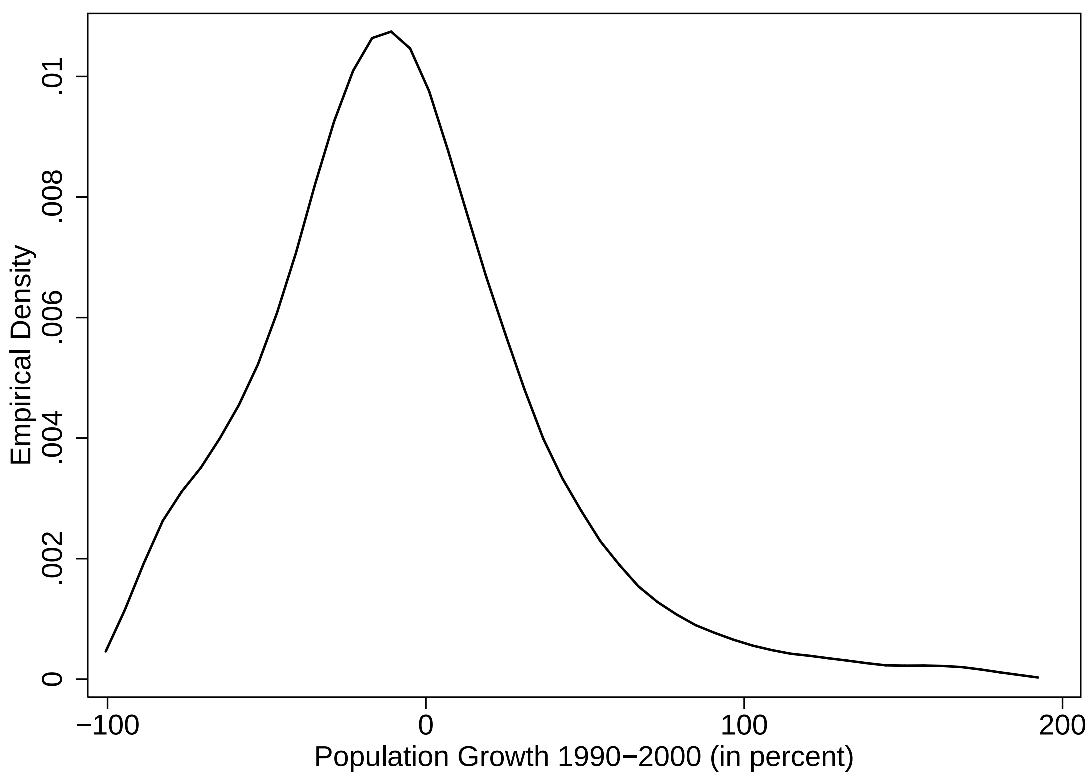

Figure 4: Distribution of population growth in ejido localities, 1990-2000

Notes: Figure displays estimated kernel density of 1990-2000 population growth (in percent) for localities in ejidos. The top and bottom 1% of localities were trimmed for estimation of the density.

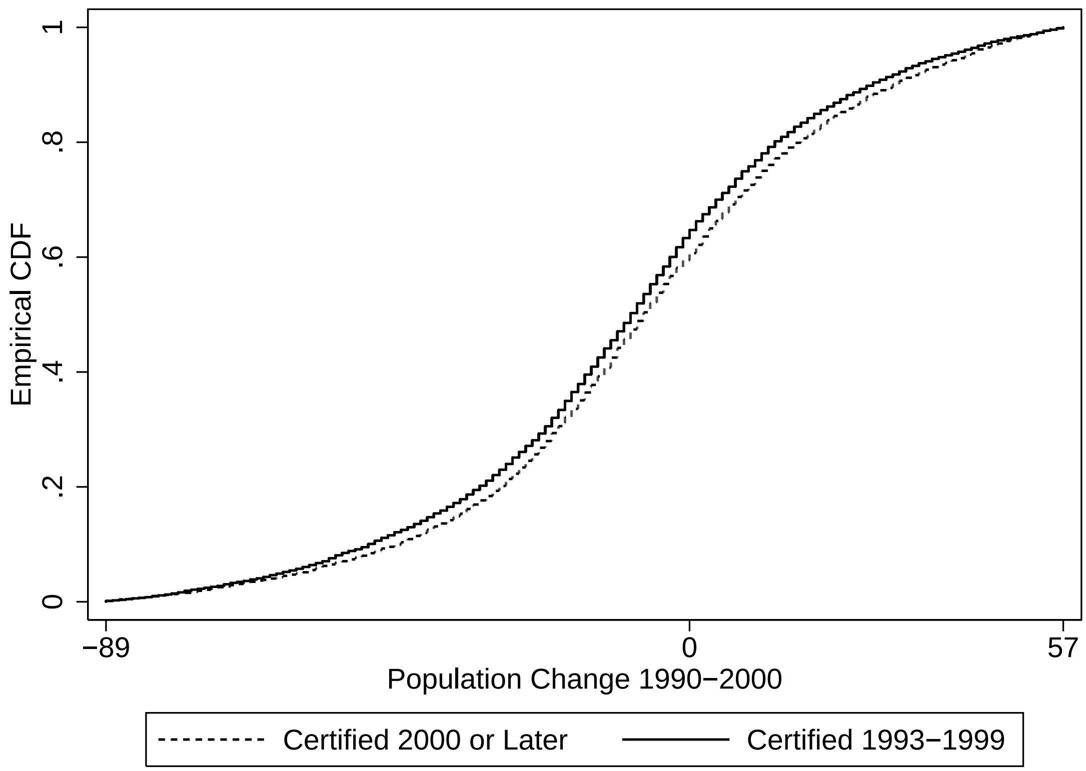

Figure 5: Cumulative distribution of population change, 1990-2000, by certification date

Notes: Figure displays empirical CDF of population change (in levels) from 1990-2000. Data used are the 1990 and 2000 locality-level population censuses.

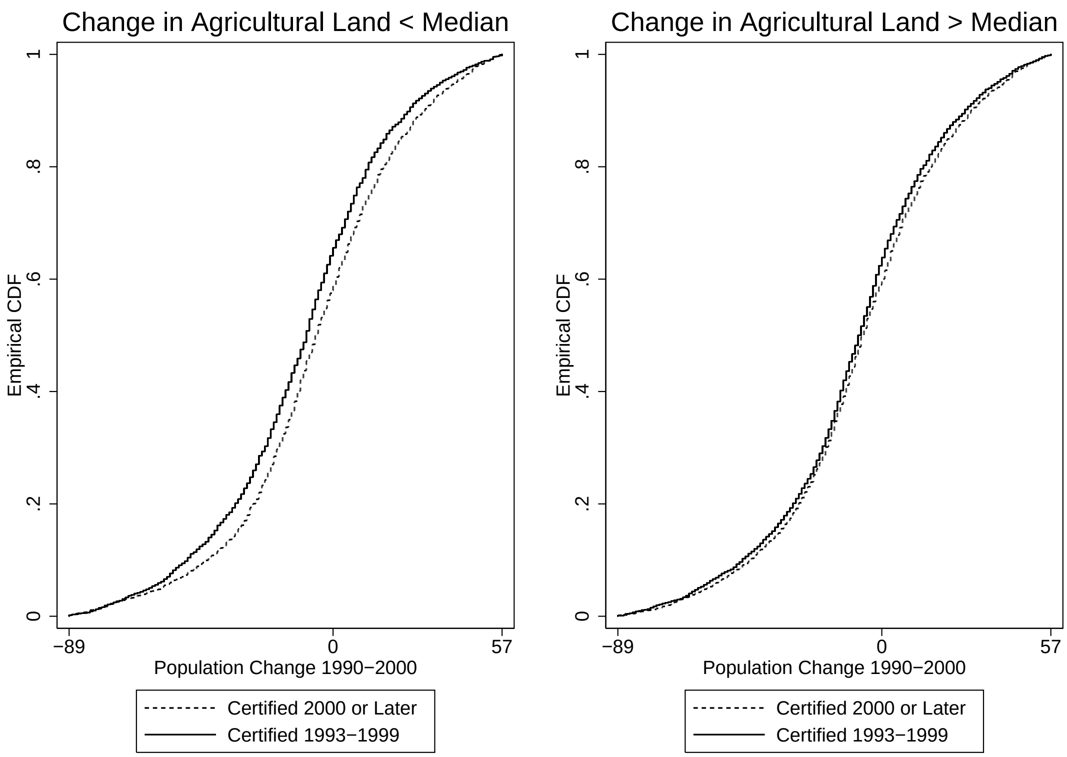

Figure 6: Empirical distribution of change in population from 1990-2000, by rank of change in log agricultural area from 1993-2007

Notes: Figure displays empirical CDF of population change from 1990-2000. Left panel is for localities in ejidos where the change in agricultural area from 1993-2007 is below the median value. Right panel is for localities in ejidos where the change in agricultural area from 1993-2007 is above the median value.

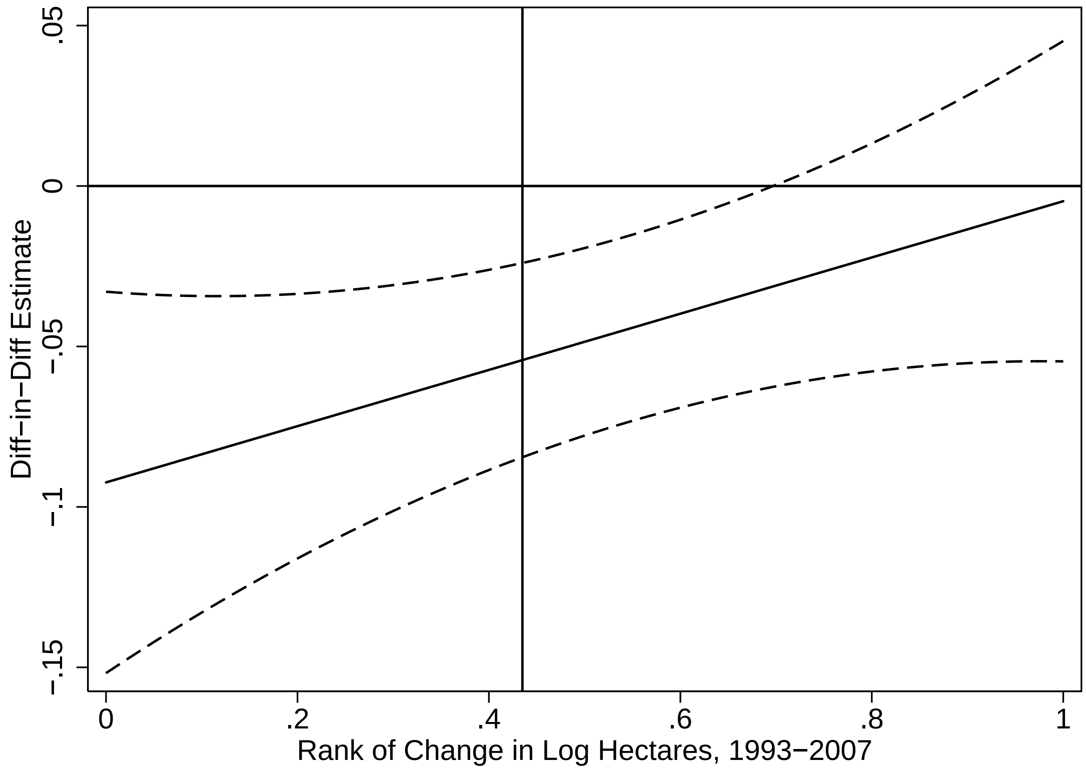

Figure 7: Difference-in-differences estimates of certification on log population by rank of change in log agricultural area from 1993-2007

Notes: Figure displays estimated marginal effect of certification on locality population as a function of the empirical CDF of change in log agricultural area from 1993-2007. Solid line is marginal effect ($= -0.0924 + 0.0876 * rank$) and dashed lines represent the 95% confidence interval. Vertical line is 43rd percentile, above which agricultural land increased from 1993-2007.