Delinking land rights from land use: Certification and migration in Mexico

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Abstract

We show that removing the link between land use and land rights through the issuance of certificates of property can result in large-scale adjustments to labor and land allocations. Using the rollout of the Mexican land certification program from 1993 to 2006, we find that households obtaining certificates were subsequently 28% more likely to have a migrant member. This response was differentiated by initial land endowments, land quality, outside wages, and initial land security. We also show that even though land certification induced migration, it did not result in decreases in cultivated area due to consolidation of larger farms.

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1 Introduction

Well-defined and secure property rights over land have long been recognized as essential for economic development (Demsetz, 1967; North and Thomas, 1973; De Soto, 2000). There are however different ways in which these rights can be established. Contrary to the norm in developed countries where rights are established by land titles, in many developing countries they are established by contingent use of the land. In this case, security of access requires evidence of productive use by the occupant himself; i.e., leaving the land idle or letting it to others implies a substantial risk of loss of rights. This can be inefficient to the occupant as it imposes conditions on the amount of labor used on the land by requiring that it be kept in production at an accepted standard of use, ignoring the return to labor in alternative activities. In addition, the common prohibition to land consolidation can be inefficient for the community if plots are below optimal size and there are increasing returns to scale. With a focus on increasing the efficiency of land use, land certification and titling programs that remove constraints on land use and allow land transactions have been widely sponsored by national governments and international development agencies (Heath, 1990).

While the impact of these titling programs on investment incentives has received significant attention, this has not been the case for the potentially large effects on the spatial reallocation of labor away from agriculture. The importance of this effect becomes clear once one considers that in developing countries value added per worker is on average four times higher in the non-agricultural sector than in agriculture (Gollin et al., 2014). At the same time, the labor share in agriculture is often several orders of magnitude larger than agriculture's share of value added. Recent literature has argued that this apparent misallocation of workers is an important determinant of cross-country income differences (Restuccia, Yang, and Zhu, 2008; Duarte and Restuccia, 2010; McMillan and Harttgen, 2014). For the specific case of Mexico that we consider in this paper, in the early 1990s, agriculture accounted for only 3.8% of GDP while 34.4% of the population lived in rural areas. This begs the question of whether improving property rights to agricultural land can be a factor that leads to a more efficient allocation of the work force.

In this paper, we argue that a pre-title regime where use-based property rights require presence of the owner on the land and his active use of the land create a distortion, inefficiently tying labor to the land, and causing too much labor to be allocated to agriculture.[1] We use a simple household model to show that implementation of a land certification program delinking land rights from land use can lead to increased outmigration. In the model, the inefficient labor tying result rests on

[1]There are many examples of use-based property rights with implications on the efficiency of land use. In Brazil, cultivation of more than 50% of the potentially productive area in large farms is required by the constitution of 1988 as a "social obligation" of land ownership, with the legal right to expropriation at the demand of spontaneous occupants if deemed under-used. By contrast, occupants making active use of the land cannot be removed as long as they are growing crops (Navarro, 2009). In China, under the household responsibility system introduced in 1978, land belongs to the community and individual farmers have usufruct rights that can be subject to expropriation. Households engaging in off-farm employment are more likely to see part or all of their land reallocated to others (Rozelle and Li, 1998). In Ghana, Goldstein and Udry (2008) find that land cannot be left idle over long fallow periods to restore soil fertility by occupants with less secure property rights due to their weaker social position in the community.

two main conditions: a preexisting suboptimal farm size and the direct land use requirement. We formalize the latter by requiring a minimum agricultural yield in order to maintain land ownership. This contrasts with the classic model where tenure insecurity is modeled as a tax on output (Besley and Ghatak, 2010). Under the traditional framework, improving property rights would be predicted to increase the marginal products of agricultural land and labor, decreasing incentives to migrate.

We test the model's predictions using data from Mexico's large-scale land certification program, the Programa de Certificación de Derechos Ejidales y Titulación de Solares, or Procede. The program was rolled out nationwide from 1993 to 2006 to issue certificates of ownership over ejido land. Ejidos are agrarian communities that were created over the 1914 to 1992 period as part of an ambitious land reform program in which community members (ejidatarios) were granted use and residual claimant rights over individual agricultural plots. Land plots were small to accommodate the objective of meeting the demand for land of as large a population as possible, with prohibition of both land consolidation through rental or sales and of land fragmentation by limiting inheritance to only one child. Security of access for individuals has been shown to be closely linked to usage (Gordillo, de Janvry, and Sadoulet, 1998). Land had to be used personally by the beneficiary and his family, and any land left fallow for more than two years would be granted to another beneficiary. Using land productively typically meant cultivating it in extensive rainfed corn.

Procede revoked this pattern of use-based property rights (Cornelius and Myhre, 1998). It gave ejidatarios land certificates specifying the name of the owner of each agricultural plot alongside with a GIS-based map of the plot. Certificates can be traded among community members and land consolidated in larger farms through rentals and sales. Procede was massive in scale, providing certificates to over 3.6 million families by the end of the program.

We use this large-scale land certification experiment to assess the migration and land reallocation impacts of redefining property rights from use-based to title-based. We use a fixed-effects econometric specification that compares changes in migration between households in early certified and later certified ejidos. Because the program provided certificates to the entire community simultaneously, this process eliminates concerns about selection at the individual level.[2] The main threat to our strategy is time-trending unobservables that vary differentially between early and later certified ejidos. We show identification tests that suggest that changes in migration over time prior to the program were uncorrelated with the program's rollout.[3]

Our main result is that redefining property rights to be based on formal certificates led to increased migration out of rural areas. We establish this result using three independent datasets. First, using panel data on rural households, we find that households in certified ejidos were subsequently 28% more likely to have a migrant household member. Second, using locality level data from two successive population censuses, we find that certification led to a 4% reduction in population. Third, we use a nationwide ejido census to confirm that certification led to more young

[2]This is contrary to typical land titling programs where allocation is demand driven. See for example, Alston, Libecap, and Schneider (1996).

[3]The robustness checks in section 5.1 provide further support for the parallel trends assumption necessary for identification.

people leaving the ejido for work reasons. Our estimates imply that the departure of about 70,000 people – or some 20% of the total number of migrants from these communities – can be attributed to the certification program.

With this main result established, we proceed to test four additional predictions of the model. First, we document heterogeneity in migration responses, with larger effects for households with ex-ante weaker property rights (associated with border conflicts and gender of the household head) and with more attractive off-farm wage opportunities. Second, we document that migration effects are smaller where land is more productive, consistent with the model where requiring productive use was more onerous on lower quality land. This result suggests that part of the oft-cited productivity effects of agricultural titling programs could be partly driven by selective migration. Third, we find evidence of sorting at the community level regarding who migrates based on differential land endowments. Farmers with more land were less likely to migrate as a result of the program than smaller landholders. The model predicts this differential effect, as the use restriction in the previous property rights regime was more binding for farmers with smaller landholdings. Finally, the model suggests that the difference in migration responses 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 on migration for land-rich households in high productivity areas is not statistically different from zero. In contrast, in low land productivity regions the migration effect is statistically significant for large and small landholders and of about the same magnitude.

We then build on our labor reallocation results to study the implications of certification for land use patterns. A decrease in agricultural labor is naturally expected to decrease total area sown. However, there are two countervailing forces that make this an empirical question. The first is land consolidation in a context of increasing returns to scale. By allowing consolidation of farm units, the certification program could help resolve the suboptimal farm size problem. The second is the enhanced investment effect traditionally argued in the property rights literature. Investments that are complementary to agricultural land could help expand cultivated area after the program.

We shed light on this question by using a large database on over 43 million farm support payments made to Mexican farmers during the period from 1995-2012 under the PROCAMPO program. The long time horizon of these data allow us to consider long-term changes that allow sufficient time for land consolidation or reallocation. We show that while ejidos that were certified earlier experienced larger decreases in the number of farmers from 1995 to 2012, the effects on cultivated area are much smaller and statistically insignificant. Combining these two results, average farm size increased by approximately 5-10% when comparing ejidos certified during the first few years of the program to those certified later. In addition, we use three rounds of satellite land use data to confirm that, on average, cropland in ejidos did not decrease after introduction of the program in spite of large population losses.

Our result that average farm size increased after Procede suggests that consolidation of landholdings represents an additional efficiency gain from improved property rights. However, policies such as land reform in developing countries often make farm sizes inefficiently small. Data from

the 1990-1991 agricultural census are consistent with this. Area per producer was approximately 2.75 times larger in the non-ejido sector than in the ejido sector (World Bank, 2001). We therefore expect that more efficient farm sizes is one of the channels through which land certification can affect welfare.

While the heterogeneity results are generally consistent with our model, we must caveat the exercise as there may be other models that could potentially explain the results. We conclude our analysis by considering some of the alternative explanations for our findings. One notable alternative explanation for the increased migration result is that the certification program attracted funds from outside the community through land transactions that helped finance migration by relaxing liquidity constraints.[4] We test and reject that this alternative mechanism explains increased migration after certification. We assess the role of credit constraints by comparing the effect of the certification program between randomly assigned Progresa (a conditional cash transfer program) and non-Progresa localities. Because the former experienced substantial exogenous cash inflows *before* certification, thereby mitigating liquidity constraints, the migration response should be smaller in Progresa localities once certification occurred. We do not find evidence of this in the data.[5]

Our results add new empirical evidence on an important channel through which improved property rights affect economic outcomes. In reviewing the property rights literature, Besley (1995), Besley and Ghatak (2010) and Galiani and Schargrodsky (2011) show that the benefits from well-defined and secure property rights over land can materialize through four channels: enhanced investment incentives (Alchian and Demsetz, 1973; Lin, 1992), facilitation of land trades (Besley, 1995; Deininger, 2003), increased use of land as collateral in accessing credit (Feder, Onchan, and Chalamwong, 1988; De Soto, 2000), and improved intra-household labor allocations (Field, 2007). The literature makes no clear distinction as to whether rights are established by use or by certification/titling, as long as they are well defined and secure. Yet, the difference on labor and land use can be very important: use-based rights can restrain migration out of agriculture and keep inferior land in production (Feder and Feeny, 1991). Prohibition of land consolidation can prevent capturing economies of scale and maintain low yields. We show that due to the existence of use-based property rights, labor reallocation can be a quantitatively important result of formally securing property rights with legal certificates.

Other work on property rights and labor allocation has focused on urban areas and found mixed results. Field (2007) finds that providing land titles to urban squatters in Peru resulted in an increase in the amount of labor allocated to work away from home, principally due to a reduction in the need for guard labor. In contrast, Galiani and Schargrodsky (2010) find that the provision of land titles to squatters in urban Argentina had no effect on labor market outcomes, possibly due to unconstrained labor supply prior to the reform.

[4] Angelucci (2013) shows that conditional cash transfer programs alleviate credit constraints and allow for migration of household members.

[5] Previous research has failed to document a credit access effect from banks using land as collateral after titling (Galiani and Schargrodsky, 2010; Field and Torero, 2006). The Mexican certification program was explicitly designed to limit mortgages (hence the term certification, not title) so we ignore this alternative in the paper. Early evidence on Procede also failed to find any credit access effects (Deininger and Bresciani, 2001).

A new literature that considers the migration effects of land titling (Valsecchi, 2013; de Brauw and Mueller, 2012; Chernina, Castañeda Dower, and Markevich, 2013) emphasizes the role of the acquired transferability of land rights for rental, sales, or inheritance. Our focus on the transition away from use-based rights suggests a different explanation for why households may migrate after rural land titling programs. Requirements to use the land productively had put households in a constrained optimum where too much labor was being used in agriculture. This is similar to the mechanism described by Giles and Mu (2011) for China where land reallocation by village authorities is affected by the extent of urban work. In addition, the literature has not addressed whether eliminating these requirements with formal property rights can decrease the share of labor in agriculture without affecting overall production. Our results on cultivated area and land consolidation suggest exactly this.

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

2 Land Reform in Mexico

We first discuss the conditions that existed as a result of Mexico's first major land reform. These conditions are useful in helping develop the setup for the theoretical framework that we outline in the next section. We then describe the characteristics of the second major reform which we focus on for the remainder of the paper.

2.1 The first reform

The first major land reform, carried out during the period from 1914 to 1992, was one of the largest in the world (Yates, 1981). The reform consisted of 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).[6] Once awarded, the land was managed by the ejido assembly under the guiding hand of the state. Farmers received usufruct rights to a plot for individual cultivation, access to common-use land (for forests, pastures, and surface water), and a residential lot for housing. With the objective of limiting land concentration, ejidatarios were prohibited from selling or renting their plots, even if it would have been efficient given increasing returns to scale.[7]

Importantly for our model, a key constraint imposed during this first reform was that members of ejidos had the social obligation of using land productively (Cordova, 1974). Furthermore, the

[6] The program also certified land in indigenous communities (de Janvry, Gordillo, and Sadoulet, 1997). In the remainder of the paper we do not differentiate ejidos from indigenous communities.

[7] There is evidence that a black market for ejido lands existed in some parts of the country (Cornelius and Myhre, 1998) and that regulations on direct use were abused in many cases (Gordillo, de Janvry, and Sadoulet, 1998). In spite of this, results from this study show that removing the regulations created a major discontinuity in labor allocation and land use.

Constitution itself ruled that any individual land plot that was not cultivated by its assignee in two consecutive years was to be taken away, imposing a permanent "use-it-or-lose-it" restriction. We impose this productive use constraint in our model by requiring that agricultural land meet a minimum standard of productivity defined by crop yield.

Also important for our model, the requirement to use land productively was not determined endogenously within the ejido. Rather, it was set and enforced externally to the ejido by a state-level Mixed Agrarian Commission charged with implementing the federal land reform legislation and composed of appointees of the Land Reform Secretariat, the State Governor, and the President of the Republic. The commission decided on land expropriations and allocations for the creation and operation of ejidos, and on the nomination and removal of individual beneficiaries. Land taken away from a beneficiary failing to meet the use and residency obligations would be assigned to the first person on a list of ejidatarios-at-wait.[8] Thus, the minimum productive use constraint that we impose can be considered as exogenous to local ejido conditions.

In addition to requiring physical presence and a minimum acceptable level of production, beneficiaries of the first land reform were prohibited from reallocating land through sales or rentals. The land market was therefore severely limited at the start of Procede.

2.2 The second reform

While the first reform achieved the social function of distributing small amounts of land to as many rural inhabitants as possible, it eventually led to low agricultural productivity and high levels of poverty among beneficiaries (de Janvry, Gordillo, and Sadoulet, 1997). With the impending advent of NAFTA, the Mexican government introduced a major constitutional reform in 1992 to improve efficiency in the ejido by certifying individual plots to current users. This second land reform was clearly intended to improve security of access to land by delineating individual property boundaries within the ejido, with the expectation of encouraging long-term productive investments by ejidatarios (Heath, 1990). The reform created Agrarian Tribunals to resolve conflicts over the issuance of certificates, established an ejido National Agrarian Registry where individuals would be assigned parcels in the ejido, allowed land rental and sales between ejidatarios, and established a well defined procedure to eventually turn ejido certificates into full titles that could be sold to non-ejidatarios.[9] By issuing land certificates, the program effectively delinked property rights from use requirements.

The program was national in scope and took 13 years to complete. The registration process began with officials from the Agrarian Attorney's Office (PA) approaching ejido officials and providing information about Procede. An ejido assembly was called to approve initiation of the certification process. After the first assembly, government officials from the National Institute of Statistics and

[8]Political scientists have argued that granting incomplete property rights with highly restrictive land use requirements was purposefully designed by the ruling party to create a clientelistic relationship with farmers in spite of the economic inefficiencies it inevitably entailed (Magaloni, 2006). In a recent paper, we find evidence of voting behavior consistent with that hypothesis (de Janvry, Gonzalez-Navarro, and Sadoulet, 2013).

[9]See Appendini (2002) and de Ita (2006) for a description of the reforms.

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 plots with individual ownership were submitted for approval at a final ejido assembly. Final approval resulted in issuance of ownership certificates by the National Agrarian Registry (RAN) simultaneously to all rights-holders in the ejido. Except for a few conflict zones, the program progressed remarkably smoothly.

Turning to the implications of program implementation for our econometric identification, the rollout progressed differentially over space. de Janvry, Gonzalez-Navarro, and Sadoulet (2013) investigate the correlates of program completion, showing that ejidos where the program was initiated earlier were on average smaller, had more land in parcels, were closer to large cities, were wealthier, had fewer non-voting members, and were more likely to be in municipalities politically aligned with the party of the state governor. These differences between early and late certified ejidos are not a threat to our identification strategy as long as they are largely uncorrelated with changes over time in migration. To address this concern we verify that changes over time in migration prior to the program were not correlated with the year of program completion in the online Appendix. We also interact fixed ejido characteristics with time effects in our main analysis to account for the possibility that migration changed over time due to these fixed characteristics that were correlated with timing of land certification.

3 Theory

The traditional land insecurity model treats insecurity of property rights as a tax on production. Because improving property rights in the canonical model generates a higher expected output, this naturally leads a household to optimally allocate more labor to the farm, thus reducing the equilibrium level of outmigration. Note that this result is based on the critical assumption that the household is always efficiently allocating labor between uses.

The main innovation in our model is to introduce use requirements as a condition to maintain property rights. In a context of small plot sizes (due to the initial allocation and the subsequent prohibition of land transactions), this leads to spatial labor misallocation. The model makes clear how these two conditions can cause inefficient tying of labor to land, and how relaxing the use restriction can provoke increased outmigration. Once this is established, the model is used to generate predictions about heterogenous effects which can be taken to the data. We also explore the consequences of relaxing the constraint on land rentals that was enacted simultaneously with land certification.

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 labor market at the wage w_m, from 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 When land use conditions property rights over land

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 shows that improving property rights results in an increase in farm labor and a corresponding decrease in migration.

In contrast, and in line with the nature of property rights in Mexican ejidos described above and the common form of usufructory rights across the world, we formalize the condition imposed on ejidatarios to maintain claim on the land 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 (Goldstein and Udry, 2008). 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, as shown in the online Appendix. However, we use the minimum yield requirement as it closely describes the situation in Mexico.

As typical with use-based ownership, and in particular in Mexico's pre-reform context, there is neither a rental nor a sales markets for land, and farmers are not allowed to hire workers. Hence A is the exogenously allotted land to the household during the initial phase of land reform, and h_e can only be family labor. Lack of land markets and farm sizes below the optimal scale generate 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.[10]

[10] 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 cannot be interpreted causally, the results provide suggestive empirical

Without constraint, the optimal allocation of labor 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. Note that the condition $\beta < 1$ ensures that the second order conditions for a maximum are satisfied. The minimum yield constraint requires the household to allocate a minimum amount of labor ($\underline{h_e}$) to agricultural production

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

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 return to on-farm 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 at least 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 relinquish their land and fully work off-farm:

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

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 $Y_e/h_e = w_m$

evidence consistent with non-decreasing returns to scale in this context. See also Adamopoulos and Restuccia (2014) for estimates of the efficiency cost of small farms in developing countries.

- Migrant/off-farm labor is given by:

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

For simplicity, we consider the case of a household having surplus labor relative to that needed to cultivate its land ($T - h_e - \ell \geq 0$). Because of the existence of an off-farm labor market, labor use in agriculture h_e (under either regime) solely depends on landholdings, not on family size. It is the migrant/off-farm labor that absorbs the household's surplus labor and depends on both family size and landholding size. Households with larger families and/or smaller landholdings have more members that either migrate or work in off-farm activities, but this difference is preexistent relative to the certification. Hence, in this model the migration response to the certification is not a function of family size.

The results have simple interpretations in terms of farm size 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 people 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). Second, because land transactions were not allowed prior to the Procede program, farm sizes were maintained at the originally allocated size without allowing for adjustments in response to the advent of mechanization in agriculture, which is thought to increase the optimal farm size. Third, further evidence of excess labor in ejidos comes from the 1991 agricultural census which indicates that the number of workers per hectare of land in the Mexican private sector (non-ejido) was 40% of that in the ejido sector (World Bank, 2001).

3.3 Land certificates and migration

We now study the effect of relaxing the land use constraint on labor use, abstracting from the other elements of the certification reform. We will see in sections 3.5 and 3.6 how other features of the law, including relaxing constraints on the land and labor markets and a one time incorporation of new members and conversion of land use, affect these predictions.

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 land certificates*:

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

while 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. 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 land certificate (equation 6).

3.4 Heterogeneity in migration response to certification

This simple framework can be used to obtain comparative statics predictions resulting from household level heterogeneity. We show that the predicted migration response varies with strength of the use-based property rights previously enjoyed, outside wages, farm size, and land productivity. All comparative statics results are obtained by simple differentiation of equation (6).

- More insecure property rights are reflected as a lower s and thus a larger $\underline{h_e}$. This shows that, *ceteris paribus*, there is a higher migration response when property rights in the use-based regime are more insecure.

- Higher wages lead to a higher level of migration h_m through lower optimal leisure. Higher off-farm wages also lead to larger migration responses to land certification. To see this, note that constrained agricultural labor $\underline{h_e}$ does not depend on wages, while optimal agricultural labor (h_e^*) decreases with wages.

- Variation in land quality is captured by the productivity parameter γ. Higher land quality reduces the minimum amount of labor necessary to reach the required yield under use-based rights and increases the optimal farm labor. Both effects contribute to a reduction in the excess labor imposed by use-based property rights. This suggests that farms with lower land productivity have more outmigration when moving from a use-based to a title-based property rights regime.

- Differentiation of (6) with respect to A shows that $\frac{\partial \Delta h_m}{\partial A}$ is 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, 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 landholdings (A) within ejidos, then the larger landholders should migrate less in response to certification. This can be thought of as a sorting effect in which the larger farmers are more likely to stay behind while the smaller farmers migrate more.

This expression also implies that the differential induced migration across farm sizes 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 landholders 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.

3.5 Land markets and land use

It is important to account for the legalization of land rentals when considering the effects of the reform on land use. The model we presented considered how a household with a fixed land endowment chooses between agricultural and non-agricultural labor. Under this framework, eliminating the constraint imposed by usufructory rights leads to increased outmigration and an increase in land fallowing would be a logical byproduct. In reality, Procede also made land rental and sale transactions legal.[11] While this was a formal aspect of the Mexican land reform, a more active rental market is an oft-cited result of agricultural titling programs.

Allowing for land to change hands after Procede has two effects. First, it can reduce or fully eliminate any decline in cultivated area that was expected due to the reallocation of labor away from agriculture. To see this, note that farmers with intermediate landholdings between A_1 and A_0 would be expected to increase migration and decrease cultivated area if the land market is unavailable. However, introducing the opportunity to rent land makes it optimal for some farms to increase cultivated area above their originally allotted landholdings. Under increasing returns to scale, the farmers with the largest landholdings are those with the largest marginal gains from cultivating additional area. Thus, efficiency would entail reallocation of land from smaller to larger farmers.

[11] Deininger and Bresciani (2001) report observing an increase in land rentals in 1997 compared to 1994.

Allowing land transactions, together with the commonly recognized investment incentive brought about by improved property rights, could also induce concentration of land in farm sizes beyond A_0. In this case, labor demand would further increase, and this would attenuate the migration effect that we estimate. This is the outcome suggested by the standard property rights model in section 3.2 above. The fact that we still observe a large migration effect suggests that the land reallocation from small to medium size farmers (up to A_0 in the model) dominated the land concentration in more labor intensive operations.

Second, allowing for land transactions will induce further heterogeneity in migration across households according to landholdings. The demand for additional land by larger farmers increases optimal agricultural labor use, thus decreasing the off-farm labor induced by certification. Conversely, smaller farmers that choose to rent out land will increase migration relative to the situation where the land market was unavailable.

In summary, allowing for land reallocation has the potential to undo some of the inefficiency imposed by the small farm sizes that were a feature of Mexico's first land reform. We test this explicitly in section 5.6 by estimating how the certification program affected the number of farmers, area cultivated, and average farm sizes.

3.6 Labor markets and other provisions of the reform

Before moving to the data, we should explicitly acknowledge that the model focuses on the use constraint and its effects in an environment with small landholdings (increasing returns to scale). In doing so, it leaves out several additional factors that, while relevant, cannot explain the migration responses to the reform.

Legalization of hiring labor is a feature of the reform that is not included in the model. Procede eliminated the requirement that ejidatarios must use only family labor for cultivation. If hired labor simply substituted for family labor, this would not affect aggregate community level migration. Thus, our use of locality-level data is helpful in determining whether the opening of the labor market offers an explanation for our migration results. We consider this issue in the empirical analysis.

In addition, if Procede allowed for more efficient labor markets, we would expect it to induce greater separation between household endowments and production decisions, as in Benjamin (1992). We test for this in Section 5.8, and cannot reject that the correlation between household size and cultivation was unchanged after Procede. It thus seems that the labor market has not played an important role in explaining the migration effects of the reform.

A further provision of the reform is to allow for incorporation of new members into the ejido, and on conversion of common property land into agricultural land that could be allocated to these new members as well as original members. Muñoz Piña, de Janvry, and Sadoulet (2003) show that this opportunity has been taken up by a large number of ejidos: 35% of them converted and divided some of their common property land and 42% incorporated new members. Note however that neither can explain migration. To the contrary, allowing ejidatarios to increase the size of their

agricultural plots can only reduce their potential migration. And incorporation of new members can only increase land use and demand for agricultural labor. By considering only ejidos that did not have common area to divide, Figure A4 in the online Appendix[12] shows evidence that division of the commons is not responsible for the effects we observe on migration and land use.

Finally, the view we take in the model is that credit constraints are not the mechanism through which Procede influenced migration. Some have argued that the existence of wage differentials between urban and rural areas may be explained by credit constraints to migration (Levy and Van Wijnbergen, 1995). By allowing land transactions to take place, certification could have alleviated credit constraints and allowed for more migration. We investigate this alternative mechanism empirically in section 5.8, but fail to find evidence for it.

4 Data

We use a total of six datasets in our analysis. First, 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.[13] 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 (see Figure A1). Figure A2 in the online appendix maps the rollout of Procede at the national level, helping visualize the extensiveness and national scope of the program.

The second dataset we use is the 1998-2000 Encuesta Evaluacion de los Hogares (ENCEL) surveys administered in the evaluation of the anti-poverty program Progresa.[14] 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 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. Our final data consist of an unbalanced panel of 7,577 households from ejidos that were certified after 1996.[15] 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.

[12]Figures and Tables preceded by the letter A can be found in the online Appendix to the paper.

[13]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.

[14]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 October/November 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.

[15]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.

Third, for the community level analysis, we use the 1990 and 2000 population censuses at the locality level from INEGI. Approximately 75% of ejidos completed the program between these 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.[16] These data cover all states of Mexico and therefore have broader geographic coverage than the panel of Progresa households. Approximately 62% of the localities in ejidos experienced a decline in population during the period from 1990-2000.

Fourth, we use the Ejido Census (Censo Ejidal) from INEGI that was administered to all ejidos in Mexico in the years 1991 and 2007. The 1991 and 2007 matched surveys are not publicly available and were merged by INEGI specifically for this study. Because the 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 online Appendix.

Fifth, we use data on farm support payments for the program PROCAMPO to study land cultivation and consolidation. PROCAMPO is a flagship program that was established to compensate farmers negatively affected by NAFTA. Plots that had been cultivated with major crops in the 1991-1993 production cycles were enrolled in the program (the period immediately preceding Procede) and owners were to receive fixed monetary payments per acre regardless of future crop choice (if any). This allows us to track land use among a fixed set of plots that were cultivated prior to the program and that account for much of the land in ejidos. Furthermore, because PROCAMPO payments include the name of the person claiming the payment for every plot we can track changes in farm size by summing claimed area for each owner/operator.

These data consist of approximately 45 million support payments that were made during the period from 1995 to 2012. For each payment, we observe the beneficiary's identification number, the ejido, the crop cultivated, the area cultivated, and the amount received. The data are informative of cultivation patterns in ejidos, as over 80% of ejidatarios claim PROCAMPO benefits. We successfully matched 19,409 ejidos from these data to the data on the rollout of Procede.

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 in 1993 among 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% by 2007.

[16] 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.

5 Results

We start by describing in section 5.1 how the migration effect of certification is established using three independent datasets. Following our model, sections 5.2 to 5.5 consider heterogeneous effects. We then give in section 5.6 evidence that certification led to migration without a decline in cultivated area. Finally, we consider effects on household consumption (section 5.7) and alternative mechanisms (section 5.8) that could potentially explain our results.

5.1 Impact of certification on migration

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, $Certif_{jt}$ 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 for 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 characteristic that affects migration is uncorrelated with the distribution of certificates. We provide support for the validity of this identification assumption in section 6 and through the robustness checks reported in this section.

The Progresa dataset shows that land certification led to increased migration of individual household members. In the first column of Table 1, the probability of a household having a migrant increases by 0.015 after being reached by Procede. The average rate of migration during the sample period is 5.3%, indicating that the effect of the program was to increase permanent migration by 28%.

This result is not sensitive to a variety of robustness checks. The second column 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. Importantly, the regression in column 2 also controls for an ejido-level *time-varying* measure of the value of agricultural production per hectare. One concern with our identification is that the opening of the Mexican economy due to NAFTA may confound our estimate. In particular, our estimate could be confounded by NAFTA if ejidos were affected differentially over time in a way that was correlated with the rollout of the land certification program. Since the influence of NAFTA on ejidos would operate through agricultural prices, we

use a measure of potential agricultural revenue per hectare that proxies for the impact of prices on each ejido.[17] The limited change in our main estimate when controlling for this measure of potential agricultural value suggests that NAFTA is not a confounding factor.

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 certification. In columns (4)-(6) we show that the results are robust to controlling for specific time trends more flexibly. In column (4) we allow the time effects to be specific by state. Column (5) includes interaction terms between each time effect and the household-level covariates. In column (6) we include interactions between time effects and some ejido-level characteristics that are shown in de Janvry, Gonzalez-Navarro, and Sadoulet (2013) to be correlated with the rollout of Procede. The purpose of this robustness check is to control for the possibility that the program was initiated earlier in certain types of ejidos that experienced differential changes in migration after the program due to reasons other than land certification. For example, the program was completed on average earlier in ejidos that are located closer to large cities. The fixed effects in our specification obviously account for time invariant differences due to proximity to major cities. Allowing the time effects to depend on proximity to cities further controls for differences in migration over time that are due to earlier program areas being closer to cities rather than certification. Our main result remains economically large and statistically significant after introducing several additional controls for differential time trends. Overall, the behavior of households in the Progresa dataset firmly points to land certificates increasing the probability that a household member migrates.

The second data source we use is the matched 1990 and 2000 locality-level population censuses. The locality 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 its longer time span (up to 7 years with a certificate). We first compare the evolution of locality population over time in a standard two-period fixed effects regression:

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

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

$$\begin{aligned} Pop_{jt} = {} & \gamma_j + \beta I(t = 2000) + (\delta_0 + \delta_1 Years\ Certified_j) * I(Certified\ by\ 2000_j = 1) * I(t = 2000) \\ & + \varepsilon_{jt}. \end{aligned} \tag{9}$$

[17] For each ejido, we use the allocation of land to crops according the observed allocation in 1995. The crop choices of individual farmers from the farm support program PROCAMPO were used to calculate crop shares for each ejido. We then calculate the weighted average value of a hectare of farm land as $value_{it} = \sum_{k=1}^{K} price_{kt} * yield_{k,1995} * share_{ik,1995}$, where $price_{kt}$ is the price of crop k in year t, $yield_{k,1995}$ is the nationwide yield of crop k in 1995, and $share_{ik,1995}$ is the share of the crop land in ejido i that was cultivated to crop k in 1995. Price and yield data are taken from FAOSTAT.

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:

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

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).

The regression results in Table 2 show that the program also induced migration at the community level. The first row in the table shows that ejido localities lost around 9.6 persons or 21% of their population between 1990 and 2000 (the time effect). The coefficients on the interaction term in the second row indicate 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)).[18] Similar to Table 1, column (3) shows that our estimate is not meaningfully affected when controlling for the effect of agricultural production value.

While results are less statistically precise, column (4) 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 (5) 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 late certified ejidos is statistically significant. The large difference is consistent with certification leading to initial migration and further migration after migrant networks have been 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 (6) indicates that the difference in population change in the 1980-1990 decade between early and late certified localities was very small and not significant. This similarity in pre-program population trends suggests that our estimate is not driven by pre-1990 differences in population change between early program and late program areas.

How does this estimated effect of Procede on the locality population compare to what was revealed in the selected Progresa communities? We cannot simply directly compare effects between datasets because the time periods differ. We also must be careful to measure migration effects

[18] Figure A3 shows that this effect is present across the whole distribution of change in population.

annually, rather than over a period of several years. The Progresa data document annual emigration from 1997 to 2000, in localities that were certified from 1997 onwards. The most direct comparison can thus be drawn with column (5) of Table 2 where we also estimate the program effect during this time period. The time effect shows a baseline migration of 20.7% of the population over 10 years, which corresponds to an average annual rate of 2.3%. 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 Procede led to an increase of the annual loss of population of 29% (=0.7/2.3). Recall that the average annual effect in the Progresa dataset was an increase in migration by 28%. 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 28-29%.

As a third dataset, we use 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 simply regress this indicator on the number of years the ejido was certified in 2007, and a set of control variables, including state fixed effects.

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 that does not necessitate a geographical merge. Hence, we see this as an important verification of the results presented in the previous two tables.

Results in Table A1 show a positive association between the years since certification and the probability that the majority of young people migrate from the ejido. More specifically, certified ejidos are 0.35% more likely to respond that a majority of their young people emigrate from the ejido for every year since certification. 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 percentage points due to the Procede program.

By presenting results from three independent datasets, we seek to credibly establish that delinking property rights from use requirements generated by the assignment of land certificates led to increased migration from agrarian communities. The number of households having a migrant increased by 28%, the locality population declined by 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 to the natural trend of a loss of 20.7% or 350,000 people in these communities over 10 years.

Before considering heterogeneity, we explicitly acknowledge that the exercise will not allow us to validate our model. Rather, we consider the exercise as a useful way of understanding whether the data are consistent with the model we have proposed.

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 were 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 with neighbors. Column (1) of Table 3 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 social observers 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.

These 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.[19]

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.[20] In columns (5) and (6) of Table 3 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 land 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 commonly used 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 per hectare. Columns (1) and (2) of Table 4 show that, as predicted, the migration response to certification is weaker (and almost null) in ejidos where land is more productive.

[19] One potential issue with this interpretation is that the gender of the household head may reflect the available off-farm labor of the household. In Table A2, we show that households with 1-2 young males in the age range from 17-30 are if anything, more likely to respond to the program with migration. We also show that controlling for an indicator for whether the household has 1-2 young males and an interaction between this variable and the certification indicator does not change the female household head results. Thus, the result does not appear to be due to availability of potential migrants.

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

5.5 Heterogeneity in land endowments

The model predicts a smaller migration effect for farmers with more land. Column 3 in Table 4 shows evidence that this holds in the data. The coefficient for relatively large landholders[21] is only 1/5 of that for small landholders.

The final prediction derived in the model is that large farmers in productive regions are expected to respond the least 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 estimating the effect of the program for large and small landholders (using the large landholder variable defined above). The results are striking. In low productivity areas, columns (6) and (7), 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, columns (4) and (5), 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 the size and quality of their landholdings: larger, more productive farmers stay on the farm, whereas smaller more marginal farmers respond to the removal of use requirements by having more members migrate.

5.6 Impact of certification on land use

Section 3.5 pointed out that the effects of Procede on cultivated area are more ambiguous than our model predicts on the surface. The model considered an autonomous household deciding how to allocate labor on and off the farm. The freedom provided by certification makes constrained households allocate less labor to the farm. Decreasing cultivated area is a potential byproduct of the decreasing labor share in agriculture.

However, the opening of the land market leads to two reasons why land reallocation after Procede can be expected. First, the program alleviates the problem of inefficiently small farm sizes by allowing consolidation of production units in a context of increasing returns to scale. Second, if some farmers are more productive than others, certification can allow for realization of gains from trade through land markets.

We use the data on PROCAMPO beneficiaries to investigate land consolidation. These data allow us to measure both the number of farmers actively cultivating and the total area sown at the ejido-year level. In order to allow time for potential consolidation to occur, we compare long-term changes in the number of cultivators and area between the two sample endpoints. The empirical specification is

$$\Delta ln(y_{js}) = \alpha_s + \sum_{\tau=1993}^{2004} \beta_\tau * ProcedeYear_{\tau,js} + \varepsilon_{js}, \quad (11)$$

[21]We use an indicator variable which is equal to one if a family has more land per adult than the median in the ejido in 1997.

where y_{js} is the outcome (either number of producers, total area, or average farm size) for ejido j in state s, and $ProcedeYear_{\tau,js}$ is an indicator for whether the ejido had the program completed in year τ. The estimates of β are identified from variation in program completion *within* states.[22]

The data show evidence of migration after Procede, but also show evidence consistent with consolidation of agricultural land. Figure 2 shows the estimates of β_τ for total number of farmers, total area, and area per farmer. The left panel shows a clear pattern of migration – or at least exit from agriculture – where declines in the number of farmers cultivating land were largest in ejidos that had the program completed earliest. The same pattern is however not apparent when considering area cultivated, as shown in the second panel. The third panel shows that relative to ejidos certified at the end of the program, farm sizes increased by around 10% for ejidos certified during 1995 or earlier. We interpret this as evidence of farm consolidation, suggesting that an important consequence of land certification is to reduce the prevalence of inefficiently small farms.[23]

Our second strategy to assess changes in land use is to test for aggregate changes in the amount of cultivated land in the ejido using satellite imagery from 1993, 2002, and 2007.[24] We estimate the reduced form impact of certification on the logarithm of cultivated area in a standard fixed effects framework

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

where j indexes ejidos and t refers to the year of the land use observation. The longer duration between satellite observations makes this analysis akin to the analysis of differences in (11).

Results reported in column (1) of Table 5 show that these data produce a similar result that certification had no significant effect on the total area used for agriculture within the ejido. The coefficient is actually positive, very small (0.1%), and statistically insignificant.

There is however some evidence that the area response differs by land quality. Column (2) shows that cultivated land actually increased with certification in agriculturally favorable regions but decreased (though not significant) in lower land quality areas. In column (3), we add controls for differential time trends in high and low yield areas.[25] 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.[26]

[22]The base group is ejidos for which the program was completed during 2005 or later.

[23]One alternative interpretation discussed in section 3.6 is that division of areas previously held in common led to increases in cultivated area that offset any decreases due to migration and land fallowing. Figure A4 shows that this is not the case by showing the the effects are very similar for the 25% of ejidos that did not have any common land at baseline.

[24]These data correspond to INEGI GIS land use series II, III and IV.

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

[26]In additional analysis, we use satellite images on the overall change in cultivated area from 1993-2007 to verify that the population declines after Procede are largest in areas where cultivated area declined the most (see Table

Taking all results together, the additional analysis on land use demonstrates that the multiple features of the reform interact to produce migration at the same time as land consolidation. In particular, relaxation of the minimum production constraint produces migration and a declining labor share in agriculture, while the opening of the land market induces farmers to reallocate land rather than take it out of production. Therefore, the reform succeeded in shifting labor out of agriculture without affecting overall levels of production and redirecting agriculture toward the better endowed areas.

5.7 Effects of land certification on household consumption expenditures

How does land certification affect household-level consumption? If more secure rights to land allow households to allocate labor more optimally, then this could translate into increased consumption. To investigate this, we use the consumption modules in four rounds of the ENCEL surveys from Progresa. The specific surveys were carried out in May 1998, October 1998, June 1999, and November 2000, hence they allow us to capture any short run effects on consumption. Each survey had a detailed consumption module that allows us to calculate monthly expenditures per household member for both food and nonfood items.[27] 43% of the households from our main sample had the program completed in this interval.

While we do not observe an effect on overall consumption across both categories, the data show a moderate increase in consumption in areas of low land quality where migration effects were the strongest. This is seen in column (2) of Table 6, with certification inducing a 7.5% increase (p=0.07) in monthly consumption per capita in low-productivity areas.

In addition, certification led to a large increase in consumption of nonfood items. While the overall effect of 4.7% in column (3) is not statistically significant, column (4) shows that nonfood consumption rose by 16.7% for households in ejidos that had been certified for at least six months at the time of the survey. In contrast to nonfood consumption, columns (5) and (6) show that Procede had no effect on the consumption of food items.

These consumption results, although modest, should be interpreted as being short term. They are also useful in ruling out a political economy story in which the most powerful ejidatarios obtained a disproportionate share of ejido lands during the land registration process by driving out weaker ejido members. Increased consumption is inconsistent with this. While we can't definitively say that consumption effects are due to migration, the result is consistent with land certification allowing for a more efficient allocation of labor and thus an increase in welfare.

A3). These results suggest that migration effects correlate with land use change, but on average, the legalization of land reallocation allows for consolidation and limits effects on overall cultivated area.

[27] Nonfood items include transportation, medicine, fuel and electricity, hygiene products, clothing, and home accessories.

5.8 Alternative mechanisms from certification to migration

While the view taken in this paper has been that increased migration caused by land certification is a result of relaxing the land use constraint, there is an alternative mechanism that would also be consistent with increased migration. Namely, land certification could have relaxed liquidity constraints by allowing poor households to sell or rent their land and use those funds to finance migration.[28] While this would not invalidate the link between certification and migration, it refers to a completely different cause of increased migration. In particular, it would imply that credit constraints were the critical factor holding people in agriculture, not the land use requirement.

One way to distinguish between these two competing explanations is by taking advantage of the Progresa experiment. Progresa randomly allocated cash transfers across villages in our sample to poor households equivalent to 140% of monthly food consumption per adult (Angelucci and De Giorgi, 2009). Because the cash payments were awarded to the poorest families, Progresa would have alleviated liquidity constraints in households where the restriction was more likely to be binding. Evidence consistent with Progresa alleviating liquidity constraints and inducing migration is shown in Angelucci (2013). Table A4 verifies that this same result holds in our sample of households located in ejidos.

We exploit this variation in liquidity constraints created by Progresa to investigate whether Procede induced more migration in areas where liquidity constraints were more binding. More specifically, liquidity constraints would have been less binding in Progresa treatment villages when Procede arrived.[29] Hence if liquidity constraints explain our results, then we should observe *smaller* effects of certification in Progresa treatment villages. We test for this by estimating the following regression for the sample of poor households that were eligible for Progresa:

$$y_{ijt} = \delta_1 Certified_{jt} + \delta_2 Certified_{jt} * Progresa_{jt} + \gamma_j + \alpha_t + \varepsilon_{ijt}. \tag{13}$$

An estimate of $\delta_2 < 0$ would be evidence that liquidity is the mechanism causing certification to increase migration. Note that the ejido fixed effects allow for the direct effect of Progresa on migration that is shown in Table A4.[30]

The results in columns (1) and (2) of Table 7 do not support the liquidity constraints explanation of our results. The specification in column (1) shows that if anything, the migration effect is *larger* in Progresa treatment villages. The same story holds in column (2) where we allow for differential

[28] In the context of Mexico, McKenzie and Rapoport (2007) have shown that migration to the U.S. is related to wealth.

[29] Note that in our Progresa estimation sample we are only using the survey rounds in which Progresa had already been implemented -the baseline round had no information on migration outcomes-, whereas Procede occurs within the sample period, hence any effects of Progresa are absorbed by the ejido fixed effects.

[30] We use ejido fixed effects to maintain consistency with our previous specification. Fully absorbing the direct effect of Progresa would require locality fixed effects. The practical difference between ejido and locality fixed effects is minimal because the match between localities and ejidos is near one to one. To demonstrate this more clearly, we regressed the Progresa treatment locality indicator on the set of ejido fixed effects for the period from 1998-2000 when payments were distributed to treatment localities. Ejido fixed effects explain 98% of the variation in Progresa treatment at the locality level.

time trends in Progresa treatment villages. We hence reject the hypothesis that Procede simply relaxed liquidity constraints and allowed people to migrate.

5.9 Rural labor markets

Hiring outside labor was technically illegal prior to Procede. One possibility is therefore that ejido households substituted hired labor for family labor, thus allowing family members to migrate. However, recall that the estimates from the locality level regressions (which correspond to net migration) were of similar order of magnitude to the individual household estimates. This suggests that substituting hired labor for family labor was not an important phenomenon in the data.

We can nonetheless inquire whether Procede led to more efficient rural labor markets. Benjamin (1992) shows that frictions in rural labor markets generate non-separation between production and consumption decisions. In our context, the correlation between household size and the amount of land cultivated can be expected to decrease after completion of Procede. The 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. We estimate:

$$Hectares_{ijt} = \beta_0 Certif_{jt} + \beta_1 Adults_{ijt} + \beta_2 Adults_{ijt} * Certif_{jt} + \gamma_j + \mu_t + x_{ijt}\alpha + \varepsilon_{ijt}, \quad (14)$$

where $Hectares_{ijt}$ is land cultivation and $Adults_{ijt}$ is the time-varying number of adults in the household. A negative and significant estimate of β_2 would suggest an increased separation between the household as a firm and the household as a consumer, which would be interpreted as working through rural labor markets. The estimate in Column (3) of Table 7 shows that the correlation between household size and cultivation does not decrease significantly after program completion. Thus the data are consistent with the certificates liberating family labor from the farm, but not with hiring in of workers to substitute for family labor.

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:

$$\Delta y_{jt} = \gamma + \alpha_t + \sum_{k \geq t} \delta_k I(Procede\ Year_j = k) + \varepsilon_{jt} \quad \forall t \leq Procede\ Year_j. \quad (15)$$

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 cover the years 1997 to 2000, only three such variables are necessary for the ejidos certified in 1999, 2000, or after 2000.[31] *Procede Year* effects that are jointly significant would indicate that year of program completion was correlated with pre-program changes in migration.

There is no evidence that pre-program changes in migration were correlated with program completion. In Table A5 we report results separately for changes in migration from 1997-1998, 1997-1999, and 1997-2000. Year of program completion does not significantly explain pre-program changes in migration in either of the three regressions. 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 might simply reflect reversion to mean migration levels. 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 (Ashenfelter, 1978):

$$y_{jt} = \gamma_j + \alpha_t + \beta_0 \cdot \mathit{(Year\ of)}_{jt} + \beta_1 \cdot \mathit{(Year\ before)}_{jt} + \beta_2 \cdot \mathit{(2\ Years\ before)}_{jt} + \varepsilon_{jt}, \qquad (16)$$

where y_{jt} is average migration at the ejido level, and other variables are indicators for the year of, year before, and two years before program completion. The β coefficients indicate whether migration levels were significantly different than average in the ejido during the years directly before the program.

We do not find evidence of this. Column (4) of Table A5 gives the results. The point estimates are very small and statistically insignificant (the smallest p-value is 0.84), 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 cannot 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.

Finally, 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.[32] In Table A6 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

[31] 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.

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

migration effect we estimate could be due to selective attrition.

7 Conclusions

Delinking land rights from land use has been the focus of a number of large land certification programs. In this paper, we showed that if property rights were tied to land use requirements in the previous regime, these policy reforms 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 farmers on about half the country's farm land.

We used three independent datasets to document a strong migration response in agricultural communities where certificates were issued. Families that obtained certificates were subsequently 28% more likely to have a migrant household member and the locality's overall population fell by 4%. The estimated effect increased over time. In addition, we documented heterogeneity in migration effects according to the ex-ante level of property rights insecurity, level of off-farm opportunities, initial farm size, and land quality.

Building on our migration results, we also considered whether total cultivated acreage decreased after the program. We found that, on average, the program did not lead to decreases in cultivated area. Combining this with the migration results, land certification led to consolidation and larger average farm sizes.

Overall, the evidence shows that certification of ownership increases the efficiency of labor allocation across space by inducing smaller and lower productivity farmers to migrate, while leaving higher productivity farmers in place and allowing them to cultivate more land. Because smallholder farmers are the ones most likely to leave after certification, efficiency gains are accompanied by immediate benefits for them. These results are consistent with a model where the key constraint imposed by insecure property rights is the requirement of continued presence and cultivation . The empirical evidence is not consistent with alternative explanations such as liquidity constraints or better-functioning labor markets.

Our results suggest that the permanent reallocation of labor between sectors of the economy can be an important pathway through which formal land rights affect economic performance. This adds to the literature on property rights which focuses on investment and increased access to credit as key pathways between rural land reform and economic growth (Galiani and Schargrodsky, 2011). The importance of agricultural labor productivity in explaining variation in aggregate output across countries suggests that enhancing agricultural labor productivity and allowing for consolidation of farmland into larger units can possibly have large effects on growth (Restuccia, Yang, and Zhu, 2008; Adamopoulos and Restuccia, 2014). Our results indicate that removing the barriers to migration through property rights reforms is one way to achieve this.

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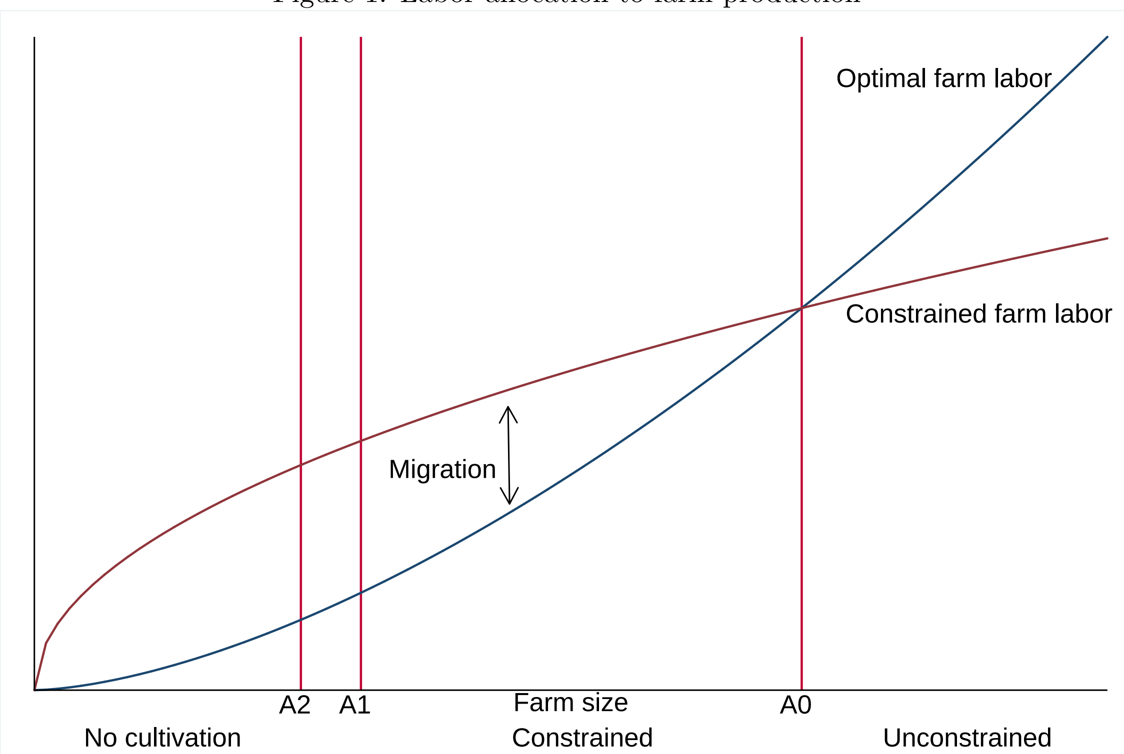
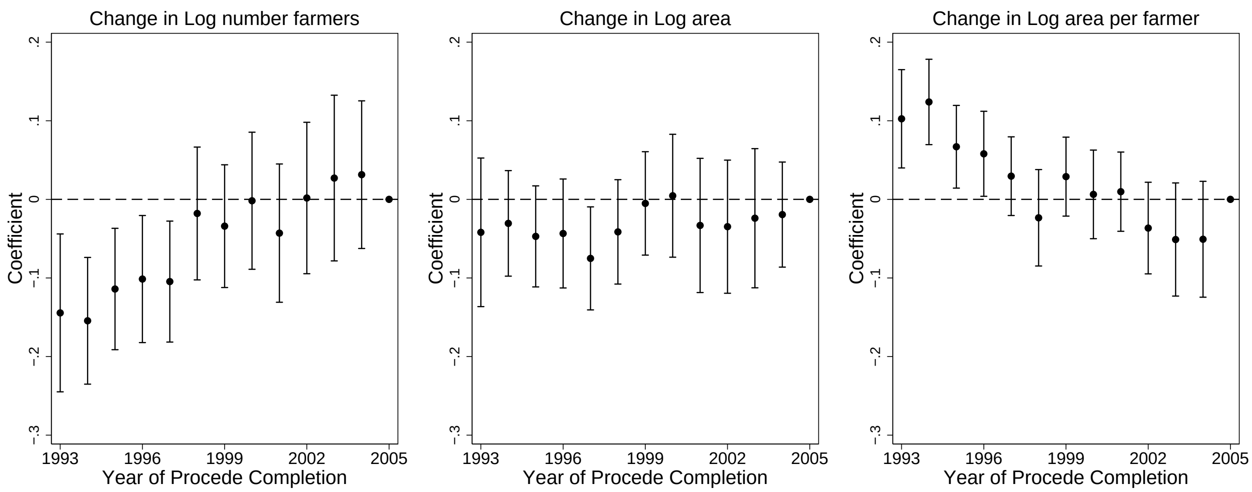
Figures and Tables

Figure 1: Labor allocation to farm production



Notes: Figure shows the optimal agricultural labor schedule as a function of farm size. *Optimal farm labor* is labor use under the title-based regime. *Constrained farm labor* is labor use under the minimum production constraint. See Section 3 for other details on theoretical model.

Figure 2: Effect of Procede on changes in the number of cultivators and area cultivated from 1995-2012



Notes: Figure shows coefficient estimates from changes in log number of cultivators and total area cultivated from 1995-2012 on year of Procede completion indicators and state fixed effects. The standard errors are clustered at the municipality level. The omitted category is 2005 and onwards, thus coefficient estimates are relative to ejidos that were completed near the end of the program.

Table 1: Effect of Procede on household migration behavior

	Progresa Households Matched to Ejidos					
	(1) Has Migrant	(2) Has Migrant	(3) Has Migrant	(4) Has Migrant	(5) Has Migrant	(6) Has Migrant
Certified	0.0149^{**}	0.0147^{**}	0.0153^{**}	0.0172^{***}	0.0157^{**}	0.0130^{**}
	(0.0061)	(0.0066)	(0.0062)	(0.0059)	(0.0063)	(0.0062)
HH is Landholder		0.0136^{***}			0.0048	
		(0.0046)			(0.0053)	
Number Males 17-30 in HH		0.0185^{***}			0.0088^{**}	
		(0.0046)			(0.0037)	
HH Head is Female		0.0132			0.0092	
		(0.0106)			(0.0082)	
Age of HH Head		0.0009^{***}			0.0004^{***}	
		(0.0002)			(0.0001)	
Agricultural value (100 USD/ha)		0.0227				
		(0.0230)				
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	0.055	0.053	0.053	0.056	0.053
Number of Observations	27189	23421	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 distance to nearest large city (population > 100,000), number of ejidatarios, number of posesionarios + avecindados, total size of the ejido, share of ejido land in parcels, locality marginalization index, longitude, and latitude.

Table 2: Effect of Procede on locality-level population

	Census Localities Matched to Ejidos					
	(1) Population	(2) ln(Population)	(3) ln(Population)	(4) ln(Population)	(5) ln(Population)	(6) ln(Population),1980-1990
Year=2000	-9.6309***	-0.2069***	-0.1986***	-0.2069***	-0.2069***	
	(1.0014)	(0.0105)	(0.0184)	(0.0105)	(0.0105)	
Certified 1993-1999*Year=2000	-3.6893***	-0.0404***	-0.0341**	-0.0206		
	(1.1485)	(0.0128)	(0.0167)	(0.0195)		
Agricultural value (100 USD/ha)			0.0036			
			(0.0077)			
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	Yes
Mean of Dep Variable	99.111	4.271	4.277	4.271	4.271	4.416
Number of Observations	34656	34656	24170	34656	34656	24910
R squared	0.014	0.035	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 1-5 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 6 is based on 12,455 localities with available population data in 1980 and with a population larger than 20 in 1980.

Table 3: 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 4: 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	(7) Has Migrant
Certified	0.0298***	0.0312***	0.0234***	0.0159*	0.0201**	0.0351***	0.0370***
	(0.0097)	(0.0101)	(0.0076)	(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])			-0.0187*	-0.0240*	-0.0339**	-0.0095	-0.0145
			(0.0097)	(0.0122)	(0.0157)	(0.0157)	(0.0164)
Land per Adult > Median in Ejido [1997]	0.0061	0.0061	0.0098*	0.0134*	0.0035	0.0038	-0.0007
	(0.0051)	(0.0051)	(0.0051)	(0.0073)	(0.0057)	(0.0058)	(0.0045)
Ejido Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects*Land per Adult > Median in Ejido	No	No	No	No	Yes	No	Yes
Time Effects*High Maize Yield Municipality	No	Yes	No	No	No	No	No
Mean of Dep Variable	0.056	0.056	0.056	0.057	0.057	0.054	0.054
Number of Observations	24372	24372	24372	14533	14533	9839	9839
R squared	0.058	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, 2 and 3 are for all matched ejidos in the Progresa sample. Columns 4 and 5 are for ejidos in municipalities with average maize yields above 1.293 tons/hectare. Columns 6 and 7 are for ejidos in municipalities with average maize yields below 1.293 tons/hectare.

Table 5: Effect of Procede on agricultural land use

	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 Municipality		0.0209**	0.0332*
		(0.0093)	(0.0182)
Ejido Fixed Effects	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes
Time Effects*High Yield Municipality	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 6: Effect of Procede on household consumption

	Log consumption per capita		Log nonfood consumption per capita		Log food consumption per capita	
	(1)	(2)	(3)	(4)	(5)	(6)
Certified	0.003	0.075*	0.047		-0.012	
	(0.032)	(0.040)	(0.054)		(0.033)	
Certified*High Yield Municipality		-0.122**				
		(0.047)				
Certified 6 months or less				-0.036		-0.028
				(0.059)		(0.039)
Certified more than 6 months				0.167***		0.011
				(0.063)		(0.037)
Ejido Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Mean of Dep Variable	4.838	4.838	3.435	3.435	4.470	4.470
Number of Observations	25482	25482	24965	24965	25373	25373
R squared	0.234	0.235	0.186	0.187	0.226	0.227

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 monthly expenditures per household member – either for all goods or food and nonfood items separately. *High Yield Municipality* is 1 if average maize yield in the municipality of the ejido is larger than 1.293 tons/ha.

Table 7: Alternative explanations of migration effect of land certification

	(1) Migration	(2) Migration	(3) Hectares
Certified	0.0138	0.0127	-0.1135
	(0.0115)	(0.0112)	(0.1670)
Certified*Progresa locality	0.0081	0.0097	
	(0.0172)	(0.0164)	
Adults in HH			0.4314***
			(0.0393)
Certified*Adults in HH			0.0296
			(0.0414)
HH head is Female			-0.4606***
			(0.0741)
Age of HH Head			0.0268***
			(0.0027)
Ejido Fixed Effects	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes
Time Effects*Progresa Locality	No	Yes	No
Time Effects*Adults in HH	No	No	Yes
Mean of Dep Variable	0.049	0.049	2.121
Number of Observations	13425	13425	24211
R squared	0.067	0.067	0.288

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. Columns 1 and 2 only include observations for poor households that were eligible for Progresa. Column 3 drops the top 1% of observations with hectares cultivated of 25 or more.

Appendix - For Online Publication

In this appendix we provide additional details on construction of some of the data used in the analysis. We also provide additional analysis supporting some of the main findings in the paper.

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 join 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.[33] 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.

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

[33] 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.

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

2. The second round of matching is meant to partially correct for the fact that matching localities to ejidos in the previous step using only the centroid of the locality is imperfect. The reason for this is that the centroid of the locality could fall outside of the boundaries of the ejido even if there is substantial overlap between the locality and ejido. Further, ejidos with multiple disjoint patches of land pose problems to matching based on locality centroids and ejido boundaries. The distance between the locality centroid for each unmatched census ejido and the center of each unmatched ejido from the GIS database was calculated using a simple distance calculation in ARCGIS. An ejido from the GIS data was matched to an ejido from the census data if the locality where the majority of the ejidatarios live was the closest locality to the center of the ejido. Since this match is not perfect, we attempt to minimize errors by only retaining matches where the percentage difference between the number of ejidatarios in the 1991 census and the GIS database was between -46.8% and 29%.[34] This round generated an additional 1,787 matches.

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.[35] 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.[36] 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.

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

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

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

Data on PROCAMPO beneficiaries

We use publicly available data from Mexico's secretariat of agriculture (SAGARPA) on the farm support program PROCAMPO to analyze land use changes after Procede. PROCAMPO entitles farmers that cultivated land during the period from 1991-1993 decoupled payments per hectare cultivated. The first payments were made to approximately 3.2 million beneficiaries during the main spring/summer growing season in 1995.

We observe each claim made by each of these beneficiaries during the period from 1995 to 2012.[37] Overall, the data contain information on 45.6 million support payments over the 18 year period. Each observation consists of the name of the farmer, numeric farmer identifier, the location as defined by state, municipality, and ejido, the crop, and area cultivated. These payments track closely the cultivation patterns of the land cultivated during the base period because the only requirement for receiving payment was cultivation of the land.

Ejidos are not identified numerically and the data are not spatially referenced. This necessitated a name match where we were able to successfully match farmers from 19,409 different ejidos to our data on program completion. The ejido-level analysis in Figure 2 uses 18,437 of the 19,409 ejidos that had observations from both 1995 and 2012.

Alternative form of land use constraint

Our model in the main text formalizes the minimum productive use constraint by requiring that ejidatarios attain a minimum yield such that $\frac{Y_e}{A} > \frac{\pi_m}{s}$. While this corresponds to the situation resulting from Mexico's first major land reform that requires that ejidatarios put land to use productively, another constraint that corresponds closely with usufructory rights in general is for farmers to be required to allocate a minimum amount of labor to agricultural land. In other words, the farmer must use the land or it is lost. In this section we describe how our predictions on heterogeneity would be affected by an alternative form of the constraint that requires $\frac{h_e}{A} \geq \mu$, where μ is a positive constant that measures the severity of the constraint.

The equilibrium allocation is nearly identical to that in the main text. That is, there are three regimes. First, agricultural labor is optimized at $h_e = h_e^*$ for the largest farmers that are unaffected by the use constraint. Second, $h_e = \mu A$ for the intermediate sized farmers for which the constraint is binding. Finally, $h_e = 0$ for the farmers that have such little land that $\frac{Y_e}{\mu A} < w_m$.

[37] We don't observe payments for the main growing season during 1998.

The migration effect of certification is

$$\Delta h_m = \mu A - h_e^* = \mu A - \left(\frac{\gamma \beta A^{\alpha}}{w_m} \right)^{\frac{1}{1-\beta}}. \tag{17}$$

We now consider how this modified form of the constraint affects the predictions on heterogeneity that we derive in the main text.

Tenure security

Since μ only increases the amount of labor required to meet the minimum use constraint, we have that

$$\frac{\partial \Delta h_m}{\partial \mu} = A > 0.$$

Thus, migration responses are also predicted to be larger for households that were more constrained under the pre-certification situation.

Off-farm wages

Similar to the case in the main text, wages affect the decision of whether to stay in agriculture prior to reform. However, non-farm wages only affect the allocation of labor to agriculture under the optimal allocation after land is certified. Thus, we see directly that

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

Land productivity

Since total factor productivity does not affect the constrained labor allocation to agriculture, we see directly from the expression for Δh_m that

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

Farm size

Differentiating Δh_m with respect to A gives:

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

$$\frac{\partial \Delta h_m}{\partial A} = \mu - \left(\frac{\gamma \beta}{w_m} \right)^{\frac{1}{1-\beta}} \left(\frac{\alpha}{1-\beta} \right) A^{\frac{\alpha+\beta-1}{1-\beta}}$$

Similar to the case in the main text, this expression can be shown to be negative except for the smallest farm sizes where $A < \left[\frac{\mu(1-\beta)}{\alpha} \left(\frac{\gamma\beta}{w_m} \right)^{\frac{1}{\beta-1}} \right]^{\frac{1-\beta}{\alpha+\beta-1}}$.

Also similar to the main text, we see that this heterogeneity with respect to landholdings is

more prominent in higher productivity areas:

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

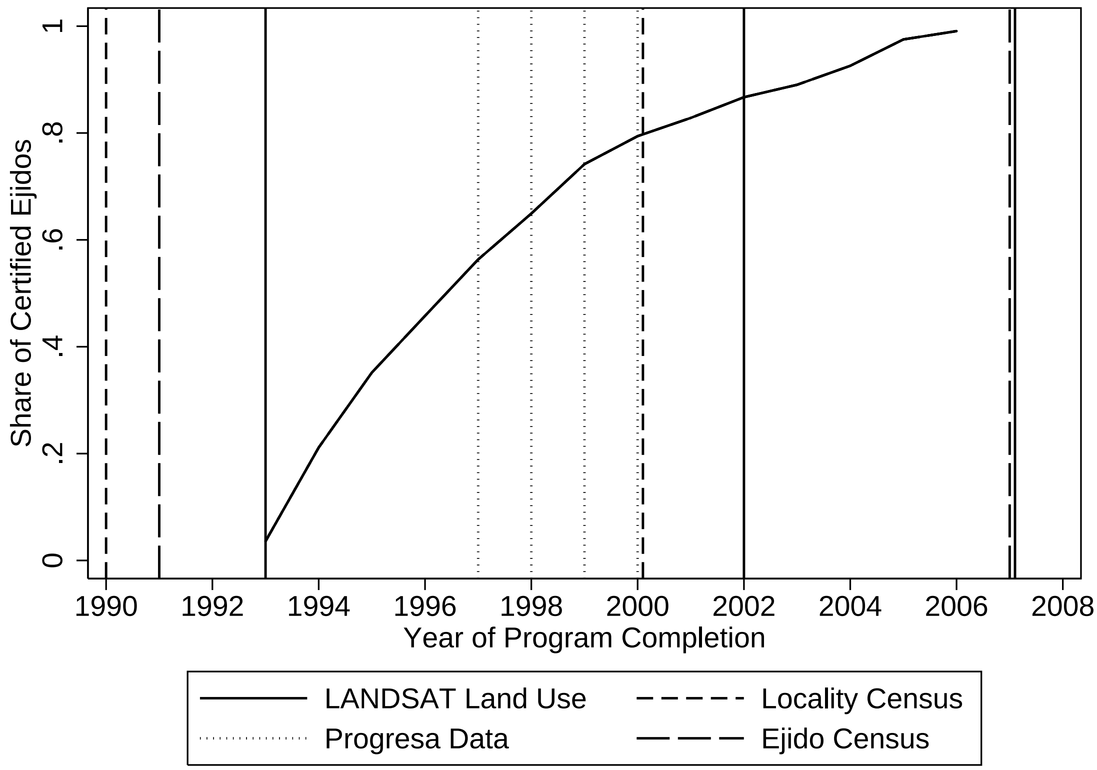
Additional analysis on land use

We show that there is a correlation between population changes and cultivated area changes. In order to do this, we consider the overall change in log agricultural land between 1993 and 2007 using the Landsat data. 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.[38] The first two columns of Table A3 repeat the fixed effects regression of locality population on whether the ejido has been certified separately for the localities with agricultural land use change below and above the median value. The table shows that the negative effect of certification on population size is much stronger in localities that also saw the largest decreases in agricultural land.

Column (3) shows that localities with the most pronounced declines in agricultural land (*rank* =0) experienced a decline in population of 9.2% in response to certification, while ejidos with the largest increases in agricultural land saw no significant effect of certification on population.

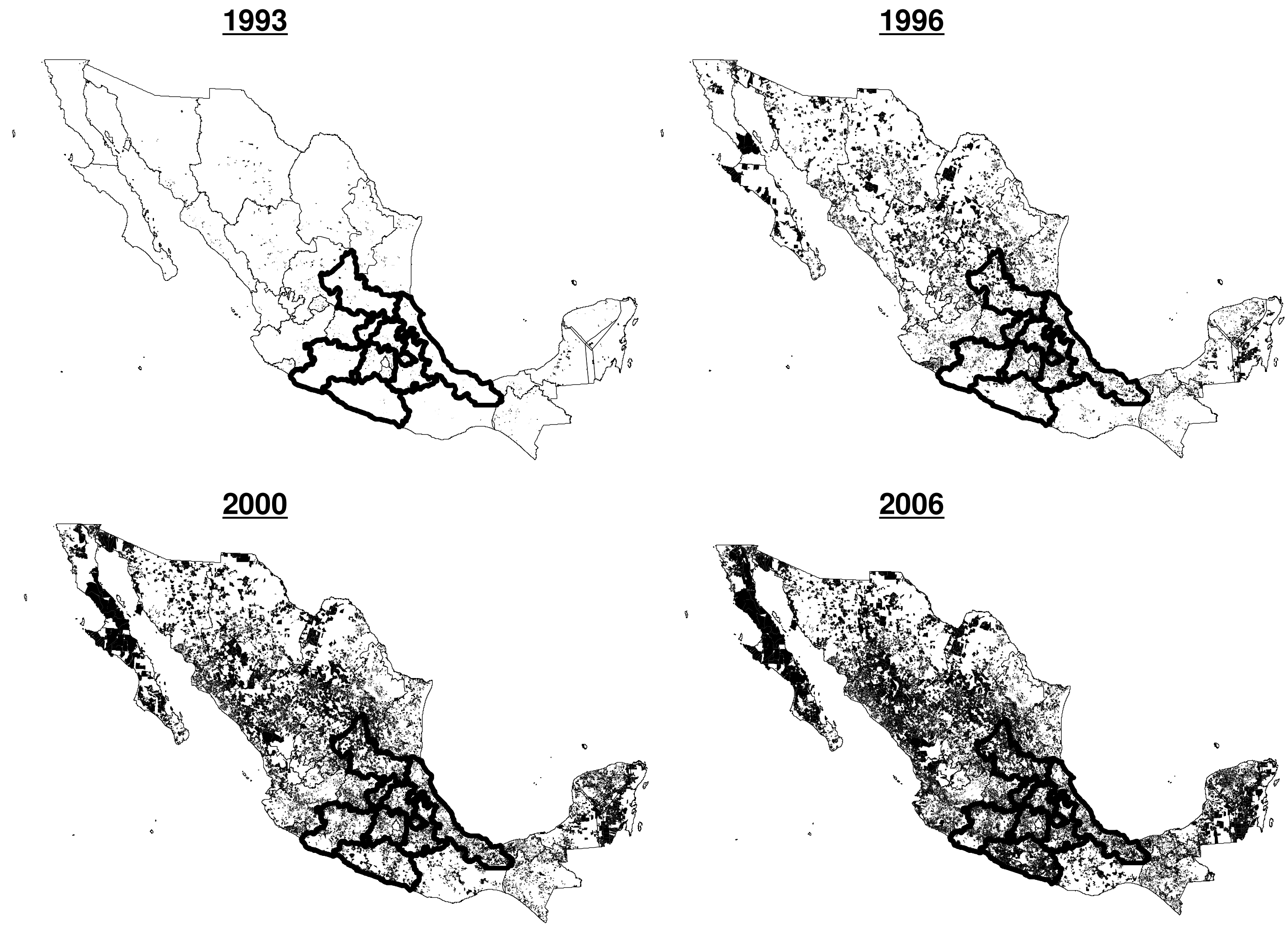
[38]The value of the variable Rank corresponds to the empirical distribution function of the change in the logarithm of agricultural land.

Figure A1: Correspondence between data and rollout of Procede



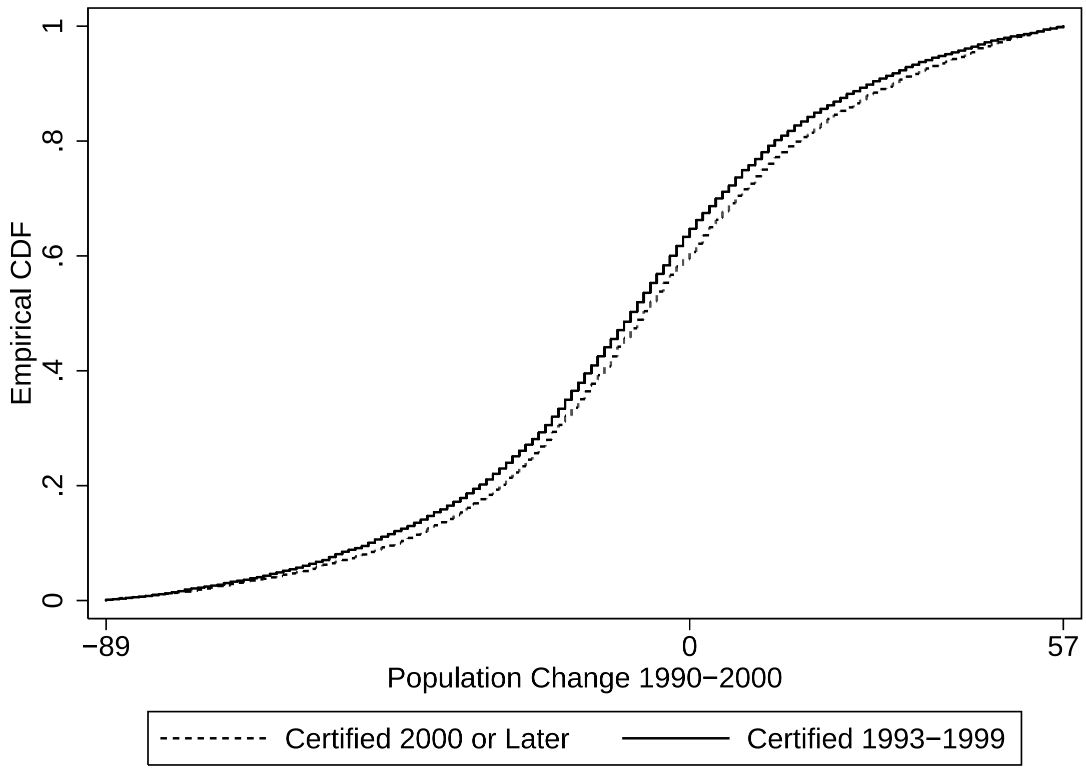
Notes: Figure shows cumulative share of ejidos certified over time. Vertical lines represent observations for each of the datasets used in the analysis. The Progresa ENCEL data are from 1998-2000. Migration recall data were used for 1997. Locality level census data are from 1990 and 2000. Ejido level census data are from 1991 and 2007. LANDSAT land use data are from 1993, 2002, and 2007.

Figure A2: Rollout of Procede across time and space



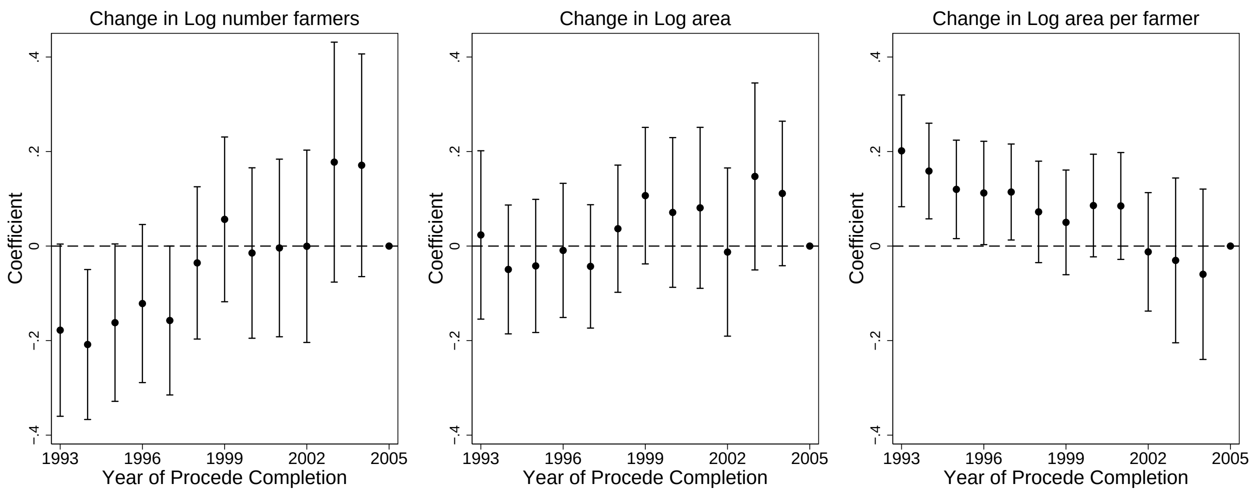
Notes: Shaded ejidos are those that completed the Procede program during or before the listed year. States with bold outlines are 7 Progresa states for which we have migration outcomes (Guerrero, Hidalgo, Michoacan, Puebla, Queretaro, San Luis Potosi, and Veracruz).

Figure A3: 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 A4: Analysis of migration and land consolidation for subset of ejidos without any common land at baseline



Notes: Figures show coefficient estimates from changes in log number of cultivators and total area cultivated from1995-2012 on year of Procede completion indicators and state fixed effects. Data are limited to areas where there was no common area prior to Procede. The standard errors are clustered at the municipality level. The omitted category is 2005 and onwards, thus coefficient estimates are relative to ejidos that were completed near the end of the program.

Table A1: Effect of Procede on ejido-level migration of young people

	Matched Ejidos in 1991 and 2007 Ejido Census	
	(1)	(2)
	Migrate	Migrate
Years Certified in 2007	0.0035***	0.0039***
	(0.0013)	(0.0013)
Using Improved Seeds in 1991		-0.0178*
		(0.0100)
Using Tractors in 1991		-0.0048
		(0.0105)
Electrical Lighting in 1991		0.0384***
		(0.0108)
Log of Distance Between Ejido and PA Office		0.0528***
		(0.0113)
State Fixed Effects	Yes	Yes
Mean of Dep Variable	0.426	0.426
Number of Observations	19670	19600
R squared	0.086	0.092

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.

Table A2: Heterogeneity according to gender and age composition of the household

	Progresa Households Matched to Ejidos			
	(1) Has Migrant	(2) Has Migrant	(3) Has Migrant	(4) Has Migrant
Certified	0.0077	0.0098	0.0003	0.0019
	(0.0076)	(0.0081)	(0.0074)	(0.0080)
Certified*HH has 1-2 young males	0.0193	0.0146	0.0227*	0.0181
	(0.0120)	(0.0139)	(0.0118)	(0.0137)
HH has 1-2 young males	0.0152**	0.0091*	0.0149**	0.0090*
	(0.0060)	(0.0049)	(0.0060)	(0.0049)
Certified*HH Head is Female			0.0625**	0.0672**
			(0.0246)	(0.0275)
HH head is Female			0.0015	0.0055
			(0.0090)	(0.0082)
Time Effects	Yes	Yes	Yes	Yes
Ejido Fixed Effects	Yes	Yes	Yes	Yes
Time Effects*HH has 1-2 young males	No	Yes	No	Yes
Time Effects*HH Head is Female	No	No	No	Yes
Mean of Dep Variable	0.056	0.056	0.056	0.056
Number of Observations	24533	24533	24533	24533
R squared	0.056	0.056	0.057	0.057

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 and age of household head as controls.

Table A3: 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 A4: Direct effect of Progresa on household-level migration

	Migration in:		
	(1)	(2)	(3)
	1998	1999	2000
Progresa locality	0.0224***	0.0221*	0.0124
	(0.0082)	(0.0128)	(0.0136)
HH is Landholder	0.0196***	0.0138	-0.0064
	(0.0073)	(0.0102)	(0.0100)
Number Males 17-30 in HH	0.0096	0.0148*	0.0175*
	(0.0063)	(0.0081)	(0.0092)
HH head is Female	0.0140	0.0071	0.0205
	(0.0169)	(0.0207)	(0.0215)
Age of HH Head	0.0010***	0.0017***	0.0017***
	(0.0002)	(0.0003)	(0.0003)
Mean of Dep Variable	0.041	0.061	0.078
Number of Observations	3509	3107	3205
R squared	0.013	0.014	0.011

Data are for all poor households that were eligible to receive Progresa payments. Dependent variable = 1 if the household had a migrant leave during the year or any previous sample year. Standard errors that allow for clustering at the locality level are reported in parentheses. Asterisks indicate statistical significance at the 1% ***, 5% **, and 10% * levels.

Table A5: Relationship between Procede and pre-program migration

	Progresa Households Matched to Ejidos, Pre-Program Period			
	(1) Δ Migration,97-98	(2) Δ Migration,97-99	(3) Δ Migration,97-00	(4) 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 A6: 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.