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Delinking Land Rights from Land Use: Certification and Migration in Mexico[†]

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In many developing countries property rights over rural land are maintained through continuous personal use instead of by land titles. We show that removing the link between land use and land rights through the issuance of ownership certificates 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 percent more likely to have a migrant member. We also show that even though land certification induced migration, it had little effect on cultivated area due to consolidation of farm units. (*JEL* O13, O17, P14, Q15, Q18, Q24, Q28)

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, with the implication that leaving the land idle or letting it to others creates a substantial risk of loss of rights. This can be inefficient for two reasons. First, 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. Second, the common prohibition to land transactions prevents land from being reallocated from less productive to more productive users. 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).

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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 nonagricultural sector than in agriculture (Gollin, Lagakos, and Waugh 2014). At the same time, the labor share in agriculture is typically much 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 percent of GDP while 34.4 percent 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 in which use-based property rights require presence of the owner on the land and his active use of the land can create a distortion, inefficiently tying labor to the land, thus causing too much labor to be allocated to agriculture.[1] Delinking land rights from land use through certification hence reduces the opportunity cost of migration. This simple point and its empirical importance contrast with the classical secure property rights argument (c.f. Besley and Ghatak 2010) in which insecurity is viewed as a tax on production. In the benchmark model, improving property rights is predicted to increase the marginal products of land and labor in agriculture, decreasing the equilibrium level of migration.

We provide new evidence of the effect that property rights improvements can have on migration 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 1914–1992 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 land consolidation through rental or sales. Security of access for individuals was 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. To comply with this land use requirement, the household

[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 percent 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 this requirement is not met. 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 users with less secure property rights due to their weaker social position in the community.

had to allocate family labor to cultivation even if the marginal return to labor in agriculture was inferior to the return in nonagriculture, thus creating a distortion with too much labor allocated to farming.[2]

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 a GIS-based map of the plot. Certificates could be traded among community members and land consolidated into larger farm units 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 natural experiment to assess the migration and land reallocation impacts of redefining property rights from use-based to certificate-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.[3] Therefore, the main threat to our strategy is time-trending unobservables that vary differentially between early and later-certified ejidos. We show identification tests suggesting that changes in migration over time prior to the program were uncorrelated with the program's rollout.[4]

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 once land in the ejidos became certified, households were subsequently 28 percent 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 percent reduction in total community population. Third, we use a nationwide ejido census to confirm that certification led to more young people leaving the ejido for work reasons. Our estimates imply that the departure of about 70,000 people—or some 20 percent of the total population loss by these communities—over the 1990–2000 period can be attributed to the certification program.

We then build on our labor reallocation results to study the implications of certification for land use patterns. A decrease in agricultural labor in the community can be expected to decrease the total area sown. However, there are two countervailing forces that make this an empirical question. The first is land consolidation into larger farms and the second is the investment effect traditionally argued in the property rights literature. Investments that are complementary to agricultural land could help expand cultivated area after the program, most obviously through mechanization.

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. The long time horizon of these data allows us to consider long-term changes that permit

[2] At the extensive margin, households would choose to stay on the farm as long as their average income was higher than the average income that could be earned in off-farm activities. While those for whom this condition did not hold would leave agriculture, a significant share of the ejido population remained in rural areas as the payoff from migration was not large enough to induce them to do so, even though they would have preferred to dedicate a larger share of labor to off-farm activities.

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

[4] The robustness checks in Section IV provide further support for the parallel trends assumption necessary for identification.

sufficient time for land consolidation. We show that while ejidos that were certified earlier experienced larger decreases in the number of farmers from 1995–2012, the effects on cultivated area are much smaller and statistically insignificant.

We also use three rounds of satellite land use data to further confirm that, on average, cropland in ejidos did not decrease after introduction of the program in spite of significant population losses. Combining these two results—a declining number of farmers and no change in area cultivated—average farm size increased by approximately 5–10 percent when comparing ejidos certified during the first few years of the program to those certified later. Given the small landholdings in ejidos that resulted from giving access to land to as many farmers as possible, we can expect that larger farm sizes should result in increased labor productivity.

To assess whether the labor and land reallocations induced by certification improve welfare, we analyze the impact of certification on household-level consumption using panel data on rural households. We find evidence of a positive effect on the consumption of non-food items, giving support to the proposition that land certification allowed for a more efficient allocation of labor and land.

We conclude our analysis by considering whether the relaxing of credit constraints could explain our findings. A plausible 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.[5] We test and reject this as an explanation of our findings. We assess the role of liquidity 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.[6]

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; Leight 2015), 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 labor productivity. We show that due to the existence of

[5] Angelucci (2015) shows that Mexico's conditional cash transfer program relaxed credit constraints and helped household members migrate more.

[6] Previous research has failed to document a credit access effect from banks using land as collateral after titling (Field and Torero 2006; Galiani and Schargrodsky 2010). 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).

use-based property rights, labor reallocation can be a quantitatively important result of formally securing property rights through certificates of ownership.

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 to protect the home. 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.

A new literature that considers the migration effects of land titling (de Brauw and Mueller 2012; Chernina, Castañeda Dower, and Markevich 2014; Valsecchi 2014) 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 (2014) for China where land reallocation by village authorities is affected by the extent of urban work or by Zhao (2014) who shows that the reduction of village-wide land reallocations in China led to increased off farm labor. 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 land use. Our results on cultivated area and land consolidation suggest exactly this.

The remainder of the paper is organized as follows. In Section I we provide details on the history of land reform in Mexico. Section II describes the data. Section III presents the identification strategy and results. Section IV shows additional robustness checks and Section V concludes.

I. Land Reform in Mexico

In this section, we first discuss the conditions that existed as a result of Mexico's first land reform whose purpose was to distribute farmland to landless peasants. We then describe the second reform whose objective was to change the property rights regime from being based on usage to being based on formal land certificates.

A. *The First Reform*

The first 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).[7] 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),

[7] 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.

and a residential lot for housing. With the objective of limiting land concentration, ejidatarios were prohibited from selling or renting their plots.[8]

Importantly, a key constraint imposed during this first reform was that members of ejidos had the obligation of using the land productively (Cordova 1974). The 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. In effect, users had the obligation to invest at least a minimum amount of effort into cultivation of their plots and had to do this using family labor—sharecropping and hiring labor were prohibited.

The requirement to use the land productively was not determined endogenously within the ejido. Rather, it was set and enforced externally to the ejido by a state-level Agrarian Commission charged with implementing federal legislation. 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.[9] Thus, the constraint linking agricultural labor to land use can be considered as exogenous to local ejido conditions.

B. *The Second Reform*

While the first reform achieved its objective of distributing small plots 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 which sought to improve efficiency in the ejido by awarding certificates of ownership 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 in which individuals would be assigned their 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.[10] 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

[8] 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.

[9] Political scientists have argued that granting incomplete property rights with highly restrictive land use requirements was purposefully done 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 2014).

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

called to approve initiation of the certification process. After the first assembly, government officials from the National Institute of Statistics and Geography (INEGI) worked with the ejido to identify owners of plots and to produce GIS maps of the ejido. Any disputes over property ownership had to be resolved during this stage of the process by the agrarian courts especially created to resolve such conflicts (Deininger and Bresciani 2001). After all conflicts had been resolved, the maps showing 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 in regions of the country in which government programs are generally hard to implement, PROCEDE was rolled out remarkably smoothly.

Turning to the implications of program implementation for our econometric identification, program implementation progressed differentially over space. de Janvry, Gonzalez-Navarro, and Sadoulet (2014) investigate the correlates of program completion, showing that ejidos where the program was initiated earlier were on average smaller, had a larger share of their land in parcels, were closer to large cities, were wealthier, had fewer nonvoting 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 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 the timing of land certification.

II. 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 that were created during the certification process. GIS ejido boundaries are available for the 26,481 ejidos that completed the program during the period from 1993–2006.[11] 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. Figure 1 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 Evaluación de los Hogares (ENCEL) surveys administered in the evaluation of the anti-poverty program PROGRESA.[12] The data consist of a panel of approximately 25,000 households

[11] 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 2,500 ejidos that were left to a special program after PROCEDE closed in 2006.

[12] PROGRESA is the Mexican conditional cash transfer program started in 1997. The program is now referred to as Oportunidades or PROSPERA. 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

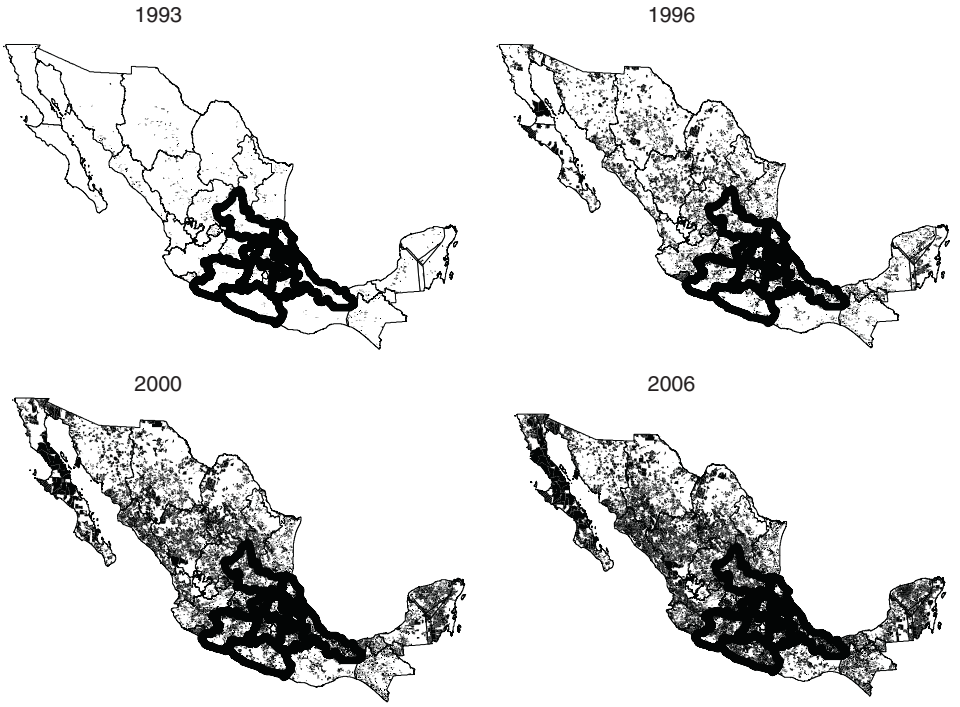

FIGURE 1. ROLLOUT OF PROCEDE ACROSS TIME AND SPACE

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

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.[13] Approximately 2.2 percent of these households had a migrant leave during 1997. Between 1998 and 2000 an additional 5.9 percent of households sent a migrant.

Third, for the community-level analysis, we use the 1990 and 2000 population censuses that were carried out by the INEGI. Approximately 75 percent 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

data were derived from recalls in the 1998 ENCEL survey. The 1997 ENCASEH baseline survey did not have comparable migration information.

[13] 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.

17,328 localities.[14] These data cover all states of Mexico and therefore have broader geographic coverage than the panel of PROGRESA households. Approximately 62 percent of the localities in ejidos experienced a decline in population during the period from 1990–2000.

Fourth, we use an ejido-level census 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 the 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 from the PROCAMPO program to study land cultivation and consolidation. This is the 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 physically cultivated 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 percent 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 GIS land use maps for the whole country.[15] The data are based on a combination of Landsat imagery taken during 1993, 2002, and 2007 and a series of field verifications. 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 percent. These figures rose slightly to 275 hectares and 32 percent by 2007.[16]

III. Results

Our main results on the effect of certification on migration are established using three independent datasets in Section IIIA. We then show the effects of the reform on cultivated area in Section IIIB. Effects on household consumption are presented

[14] 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.

[15] The data consist of Series II, III, and IV of the land use/land cover maps from INEGI.

[16] Figure A1 in the online Appendix shows the timing of the different data sources as well as the PROCEDE rollout.

in Section IIIC while Section IIID considers liquidity constraints as an alternative explanation.

A. *Impact of Certification on Migration*

First, we use 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

$$y_{ijt} = \delta Certif_{jt} + \gamma_j + \alpha_t + x_{ijt}\beta + \varepsilon_{ijt}, \tag{1}$$

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 IV.

Estimates of (1) using the PROGRESA dataset are presented in Table 1. Column 1 shows that 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 percent, indicating that the effect of the program was to increase permanent migration by 28 percent.

This basic 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]

[17] For each ejido, we use the allocation of land to crops according to the 1995 production cycle. 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 farmland as $value_{it} = \sum_{k=1}^{K} price_{kt} \times yield_{k,1995} \times share_{ik,1995}$, 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.

Table 1—Effect of PROCEDE on Household Migration Behavior

	PROGRESA households matched to ejidos					
	Has migrant (1)	Has migrant (2)	Has migrant (3)	Has migrant (4)	Has migrant (5)	Has migrant (6)
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)
Household is landholder		0.0136***			0.0048	
		(0.0046)			(0.0053)	
Number males 17–30 in household		0.0185***			0.0088**	
		(0.0046)			(0.0037)	
Household head is female		0.0132			0.0092	
		(0.0106)			(0.0082)	
Age of household 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
Household fixed effects	No	No	Yes	No	No	No
State × Time Effects	No	No	No	Yes	No	No
Household Characteristics × Time Effects	No	No	No	No	Yes	No
Ejido Characteristics × Time Effects	No	No	No	No	No	Yes
Mean of dependent variable	0.053	0.055	0.053	0.053	0.056	0.053
Observations	27,189	23,421	27,189	27,189	24,533	27,189
R^2	0.047	0.058	0.043	0.048	0.059	0.048

Notes: Standard errors that allow for clustering at the ejido level are reported in parentheses. 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 nonvoting members, total size of the ejido, share of ejido land in parcels, locality marginalization index, longitude, and latitude.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

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 (2014) 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 seven years with a certificate). We first compare the evolution of locality population over time in a standard two-period fixed effects regression:

$$(2)\quad Pop_{jt} = \gamma_j + \beta Year2000_t + \delta Certified1993 - 1999_j \times Year2000_t + \varepsilon_{jt}.$$

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

$$(3)\quad Pop_{jt} = \gamma_j + \beta Year2000_t + (\delta_0 + \delta_1 Years\,Certified_j) \times Certified1993 - 1999_j \times Year2000_t + \varepsilon_{jt}.$$

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:

$$(4)\quad Pop_{jt} = \gamma_j + \beta Year2000_t + \delta_1 Certified\,before\,1997_j \times Year2000_t + \delta_2 Certified1997 - 1999_j \times Year2000_t + \varepsilon_{jt}.$$

The dependent variable is the total population (or logarithm) of locality j in year t. The first specification (2) is a simple fixed effects regression where δ identifies the average effect of the ejido getting certification on the change in locality population. The second specification (3) 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 (4) 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 percent 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 percent 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 percent 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 percent decrease in population for early certified ejidos and a 2 percent 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 falsification test we use 12,455 localities with available population in 1980 to estimate a version of (2) 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 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 onward. 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 percent of the population over ten years, which corresponds to an average annual rate of 2.3 percent. The certification effect for those ejidos certified in 1997–1999 is an additional effect of 1.96 percent over these three years, or an average annual effect of 0.7 percent. Hence, PROCEDE led to an increase of the annual loss of population of 29 percent ($= 0.7/2.3$). Recall that the average annual effect in the PROGRESA dataset was an increase in migration by 28 percent. 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 percent.

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

[18] Online Appendix Figure A2 shows that this effect is present across the whole distribution of change in population.

Table 2—Effect of PROCEDE on Locality-Level Population

	Census localities matched to ejidos					
	Population (1)	ln(Population) (2)	ln(Population) (3)	ln(Population) (4)	ln(Population) (5)	ln(Population), 1980–1990 (6)
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 dependent variable	99.111	4.271	4.277	4.271	4.271	4.416
Observations	34,656	34,656	24,170	34,656	34,656	24,910
R^2	0.014	0.035	0.035	0.036	0.036	0.033

Notes: Standard errors that allow for clustering at the ejido level are reported in parentheses. 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.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

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 3 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 percent 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

TABLE 3—EFFECT OF PROCEDE ON EJIDO-LEVEL MIGRATION OF YOUNG PEOPLE

	Matched ejidos in 1991 and 2007 ejido census	
	Migrate (1)	Migrate (2)
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 dependent variable	0.426	0.426
Observations	19,670	19,600
R^2	0.086	0.092

Notes: Standard errors that allow for clustering at the municipality level are reported in parentheses. 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.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

assignment of land certificates led to increased migration from agrarian communities. The number of households having a migrant increased by 28 percent, the locality population declined by 4 percent, and ejidos were 0.35 percent 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 percent of them or almost 70,000 people. This should be compared to the natural trend of a loss of 20.7 percent or 350,000 people in these communities over ten years.

We also estimated heterogeneous treatment effects along three dimensions. The estimation results are presented in online Appendix Table A1, but we discuss the results briefly here. First, we wanted to determine if the migration result was stronger in ejidos that had greater levels of tenure insecurity prior to the program. As a measure of *between ejido* security, we used a question from the 1991 ejido census indicating the presence of boundary problems with neighbors. We indeed find that the migration effect of certification is more than double for households in ejidos where boundary problems were present, but this result is only significant at conventional levels if we allow for time effects to be different for ejidos with boundary problems.

Second, we explored heterogeneity with respect to land quality. In our framework, the requirement to use land productively is more onerous in places with low land productivity. We test for this using municipal level rainfed corn yield from the Ministry of Agriculture. We partition municipalities into those that are below and above average in terms of corn yield—the staple food grown with national coverage.[19] Interestingly, we find that the migration response to certification is weaker in ejidos where land is more productive. Put differently, the migration effects are mostly present in areas where baseline land productivity is low.

Finally, it is of interest to know *who* in the community migrated as a result of the certification program. We do this by splitting households within each ejido into those that have below and above median landholdings per adult. Doing this, we find that land certification has a positive and statistically significant effect on migration for relatively small landholders, but not for the larger ones. The fact that smaller landholders in the community are likely to migrate as a result of the certification program is consistent with the idea that the land use restriction was more onerous for smaller landholders. For those with more generous land endowments, the minimum use restriction was less of a constraint, so the migration response is smaller.

B. *Impact of Certification on Land Use*

Having shown that certification led to out-migration from rural communities, we now turn to the question of the effects of certification on land use. Ceteris paribus, a reduction in farm labor would be predicted to diminish total production. In other words, production would fall after certification if farmers simply fallowed all of their land or left a share of their land uncultivated. However, the certification reform not only lifted the use restriction, it simultaneously eliminated restrictions on land sales, land rentals, and sharecropping. This opened new trade opportunities within the community that allowed for both land to be reallocated from those migrating to those staying and for efficiency gains from land being allocated from lower productivity to higher productivity farmers. Hence, verifying empirically whether land was reallocated is important to determine if there is an efficiency cost of the reform in terms of land abandonment. Not only that, since small farm sizes have been pointed out as an important contributor to low farmer productivity in developing countries, it is of interest to verify empirically whether titling programs alleviate this problem.

We use the PROCAMPO data to analyze farm consolidation by summing up the area cultivated by each person in the ejido to obtain a measure of farm size. These data hence allow us to measure both the number of farmers actively cultivating and the total area sown at the ejido level. In order to allow time for potential consolidation to occur, we compare the long-term changes in the number of cultivators and area between the two sample endpoints. The empirical specification is

$$\Delta \ln(y_{js}) = \alpha_s + \sum_{\tau=1993}^{2004} \beta_\tau \times ProcedeYear_{\tau,js} + \varepsilon_{js}, \tag{5}$$

[19] This variable is only systematically available at the municipality level since 2002, so we use the 2002–2008 average corn yield to partition the ejidos.

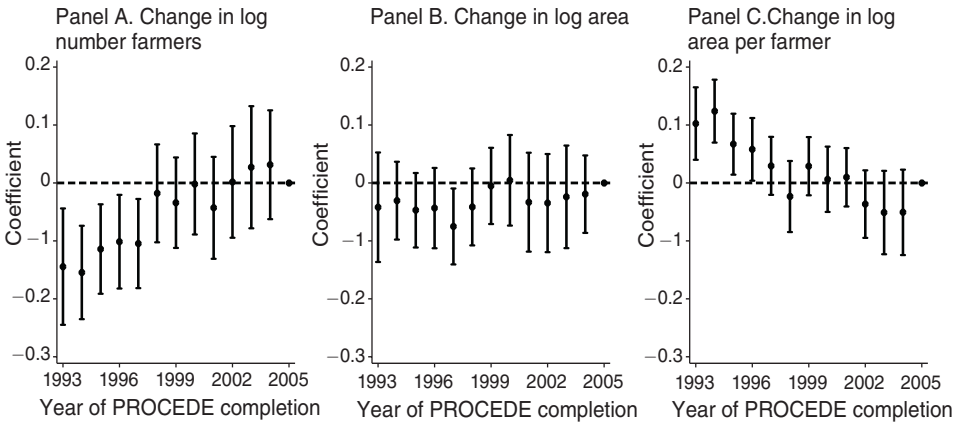

FIGURE 2. EFFECT OF PROCEDE ON CHANGES IN THE NUMBER OF CULTIVATORS AND AREA CULTIVATED FROM 1995 TO 2012

Notes: Figure shows coefficient estimates from changes in log number of cultivators and total area cultivated from 1995 to 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 onward, thus coefficient estimates are relative to ejidos that were certified near the end of the program.

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.[20]

The data show evidence of migration after PROCEDE, but also evidence that is consistent with consolidation of agricultural land. Figure 2 shows the estimates of β_τ for the 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 percent 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.[21]

Another way of assessing changes in land use at the community level is to test for aggregate changes in the amount of cultivated land in the ejido using satellite imagery from 1993, 2002, and 2007. We estimate the reduced form impact of certification on the logarithm of cultivated area in a standard fixed effects framework

$$\log(Agland_{jt}) = \gamma_j + \alpha_t + \delta Certified_{jt} + \varepsilon_{jt}, \tag{6}$$

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

[21] One alternative interpretation discussed in Section IIID 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. Online Appendix Figure A3 shows that this is not the case since the effects are very similar for the 25 percent of ejidos that did not have any common land at baseline.

Table 4—Effect of PROCEDE on Agricultural Land Use

	Landsat satellite data		
	log(Area Ag.) (1)	log(Area Ag.) (2)	log(Area Ag.) (3)
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 dependent variable	5.718	5.714	5.714
Observations	63,392	58,763	58,763
R^2	0.012	0.012	0.012

Notes: Standard errors that allow for clustering at the ejido level are reported in parentheses. The dependent variable is the log of the area in agriculture in the ejido. *High Yield Municipality* is 1 if average maize yield in the municipality of the ejido is larger than the median yield of 1.29 tons per hectare.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

where j indexes ejidos and t refers to the year of the land use observation. The long duration between satellite observations makes this analysis temporally akin to the analysis of differences in (5).

Results reported in column 1 of Table 4 show that these data produce our previous finding, namely that certification had no significant average effect on total area used for agriculture within the ejido. The coefficient is actually positive, very small (0.1 percent), 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 significantly) in lower land quality areas. In column 3, we add controls for differential time trends in high and low yield areas.[22] 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 percent. In contrast, agricultural land increases with certification in high agricultural productivity areas. The point estimate ranges from 1.3 to 1.6 percent, and the difference between favorable and nonfavorable areas is significant.[23]

Taking all results together, the 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, we argue that relaxation of the use constraint produces migration and a declining labor share in agriculture, while the opening of the land market induces farmers to reallocate land to stayers rather than take it out of production.

[22] As another robustness check on the resolution of the Landsat images, we ran all the regressions in Table 4 after dropping the smallest 5 percent of ejidos. The coefficients change only minimally and statistical significance is unaffected (results not reported).

[23] In an additional analysis, we use satellite images on the overall change in cultivated area for 1993–2007 to verify that the population declines after PROCEDE are largest in areas where cultivated area declined the most (see Table A2). These results suggest that migration effects correlate with land use change, but on average, the legalization of land reallocation allows for consolidation and limits the effects on overall cultivated area.

Therefore, the reform succeeded in shifting labor out of agriculture without affecting the overall amount of cultivated area.

C. *Effects of Land Certification on Household Welfare*

Did land certification affect household-level consumption? If more secure rights to land allow households to allocate labor and land in a more efficient manner, then this could translate into increased consumption. To investigate this, we use the consumption modules in four rounds of the PROGRESA surveys. The surveys were carried out in May 1998, October 1998, June 1999, and November 2000, hence they allow us to capture short run effects on consumption. Each survey has a detailed consumption module that allows for calculation of monthly expenditures per household member for both food and nonfood items.[24] 43 percent of the households from our main sample had the program completed in this interval.

While we do not observe a statistically significant 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 5, with certification inducing a 7.5 percent 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 percent in column 3 is not statistically significant, column 4 shows that nonfood consumption rose by 16.7 percent 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 and land consolidation, the result is consistent with land certification allowing for a more efficient allocation of resources and thus an increase in welfare.

D. *Alternative Explanations*

The argument developed in this paper is that increased migration caused by land certification is a result of relaxing the land use constraint. But there is an alternative explanation 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.[25] While this would not invalidate the link between certification and migration, it offers a completely different explanation of our results. In particular, it would imply that credit

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

[25] In the context of Mexico, McKenzie and Rapoport (2007) have shown that migration to the United States is related to wealth.

TABLE 5—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 six months or less				−0.036		−0.028
				(0.059)		(0.039)
Certified more than six 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 dependent variable	4.838	4.838	3.435	3.435	4.470	4.470
Observations	25,482	25,482	24,965	24,965	25,373	25,373
R^2	0.234	0.235	0.186	0.187	0.226	0.227

Notes: Standard errors that allow for clustering at the ejido level are reported in parentheses. 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 the median yield of 1.29 tons per hectare.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

constraints were the critical factor holding people in agriculture, not the requirement to use land in order to maintain ownership.

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 percent 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 for households where the restriction was more likely to be binding. Evidence consistent with PROGRESA alleviating liquidity constraints and inducing migration is given by Angelucci (2015).[26]

We exploit this random 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.[27] 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:

$$(7) \qquad y_{ijt} = \delta_1 Certified_{jt} + \delta_2 Certified_{jt} \times Progresa_j + \gamma_j + \alpha_t + \varepsilon_{ijt}.$$

[26] Online Appendix Table A3 verifies that this same result holds in our sample of households located in ejidos.

[27] Note that in our PROGRESA estimation sample we are only using the survey rounds in which PROGRESA had already been implemented (1998–2000), hence any effects of PROGRESA are absorbed by the ejido fixed effects.

TABLE 6—HETEROGENEOUS EFFECT OF PROCEDE ON MIGRATION ACCORDING TO PROGRESA TREATMENT STATUS

	PROGRESA-eligible households	
	Migration (1)	Migration (2)
Certified	0.0132	0.0091
	(0.0121)	(0.0130)
Certified × Progresa Treatment Locality	−0.0027	0.0046
	(0.0149)	(0.0158)
Ejido fixed effects	Yes	Yes
Time effects	Yes	Yes
Time Effects × Progresa Treatment Locality	No	Yes
Mean of dependent variable	0.060	0.060
Observations	9,913	9,913
R^2	0.071	0.071

Notes: Standard errors that allow for clustering at the ejido level are reported in parentheses. Both columns only include observations for poor households that were eligible for PROGRESA.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

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 online Appendix Table A3.[28]

The results in columns 1 and 2 of Table 6 do not support the liquidity constraints explanation of our results. The point estimate on the interaction term in column 1 is small and statistically insignificant. The point estimate on the interaction term in column 2 becomes positive when we allow for differential time trends in PROGRESA treatment villages. We hence reject the hypothesis that PROCEDE simply relaxed liquidity constraints and allowed people to migrate.

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 to original members. Muñoz-Piña, de Janvry, and Sadoulet (2003) show that this opportunity has been taken up by a large number of ejidos: 35 percent of them converted and divided some of their common property and 42 percent 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. However, this feature of the reform could potentially explain the null

[28] 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 percent of the variation in PROGRESA treatment at the locality level.

effect on cultivated area. By considering only ejidos that did not have common area to divide, Figure A3 in the online Appendix shows that division of the commons was not responsible for the effects we observe on land use patterns.

IV. 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 a 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:

$$(8)\quad \Delta y_{jt} = \gamma + \alpha_t + \sum_{k \geq t} \delta_k I(ProcedeYear_j = k) + \varepsilon_{jt} \quad \forall t \leq ProcedeYear_j.$$

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, $ProcedeYear_j = k$, for the year in which the program was completed in the ejido. Since the data cover the years 1997–2000, only three such variables are necessary for the ejidos certified in 1999, 2000, or after 2000.[29] *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 online Appendix Table A4 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):

$$(9)\quad y_{jt} = \gamma_j + \alpha_t + \beta_0 \cdot (Year\,of)_{jt} + \beta_1 \cdot (Year\,before)_{jt} + \beta_2 \cdot (2Years\,before)_{jt} + \varepsilon_{jt},$$

[29] 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.

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 A4 in the online Appendix 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 PROGRESA survey. 11.2 percent of households with an interview completed in 1998 did not have an interview completed in 1999. The percentage rose slightly to 12.7 percent in 2000.[30] In Table A5 in the online Appendix we run the basic regression used to identify the role of PROCEDE on migration, equation (1), on attrition. The effect of certification on attrition is both small and statistically insignificant. There is therefore no evidence that the migration effect we estimate could be due to selective attrition.

V. 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 1993–2006, awarded ownership certificates to farmers on about half the country's farmland.

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 percent more likely to have a migrant household member and the locality's overall population fell by 4 percent. The estimated effect increased over time. In addition, we documented heterogeneity in migration effects according to the ex ante level of property rights insecurity, initial farm size, and land quality.

Building on the 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 indicates that land certification led to consolidation and larger average farm size. Verifying that household consumption increased in the context of certification suggests that these resource reallocation effects were sources of efficiency and welfare gains.

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

These 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 have large effects on growth (Restuccia, Yang, and Zhu 2008; Adamopoulos and Restuccia 2014). Our results indicate that removing the constraints to labor allocation and land transactions through property rights reforms that delink land rights from land use is one way to achieve this.

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