Conserving the Amazon by Titling Indigenous Communities: Evidence from Bolivia, Brazil, Colombia, and Ecuador

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ABSTRACT

Motivation. Increasingly, developing countries, particularly those in Latin America, are decentralizing forest governance by granting local communities formal legal title to land. Almost a third of forests in the global south are now managed by local communities, well over twice the fraction assigned to protected areas. Titling land managed by indigenous groups is among the leading mechanisms being used to implement decentralization in Latin America.

Yet we know little about the effects of community titling on forest loss, which remain an urgent problem. Related theoretical and empirical research suggests that it could either stem or spur deforestation. On one hand, it has long been known that ill-defined property rights can create incentives for agents to overexploit natural resources. In principle, granting title to native communities could mitigate that problem. But on the other hand, titling may enhance communities' access to credit and other inputs used for clearing forests, and/or leave them vulnerable to being coopted by more powerful public and private sector actors. Hence, the net effect on forest clearing and degradation of titling local communities is an empirical matter. To our knowledge, an quantitative analysis of the effect of a large-scale community titling initiative has yet to appear.

We examine the link between providing formal land title to indigenous communities and 2000-2012 deforestation in the Amazon region in four countries: Bolivia, Brazil, Colombia, and Ecuador. We use fine-scale data derived from satellite images to measure deforestation along with statistical techniques (propensity score matching) that aim to disentangle the effects of land-titling from those of pre-existing characteristics of the indigenous community land that affect deforestation, including population density and proximity to population centers.

Empirical approach. The main challenge we face in attempting to measure the effect on deforestation of the titling of indigenous communities is the usual one in program evaluation: the treatment—here titling—is not randomly assigned. Rather, as our data illustrate, for the most part, community titles have been assigned to land with preexisting geophysical and socioeconomic characteristics that stem deforestation. A failure to control for the fact would conflate titling's effects on deforestation with the effects of the preexisting characteristics of the land, thereby generating a biased result. For example, in Bolivia, compared to land outside, land inside indigenous communities tends to be farther from large population centers, less populated, and in areas with relatively low opportunity costs, all characteristics that typically slow deforestation. Unless we controlled for these characteristics, we would give all of the credit for relatively low rates of deforestation inside indigenous communities to the titling of these communities, when at least part is due to these land characteristics.

To help control for such bias, we use matching techniques. We first select a quasi-random sample of points inside and outside of indigenous communities in a study area. Next, we construct a subsample of matched control points outside indigenous communities that are observationally similar to the points inside and we measure the effect of tilting—the average treatment effect on the treated (ATT)—by comparing the average rates of deforestation on points inside indigenous communities and matched points outside.

To ensure robustness, we use three matching estimators: nearest neighbor one-to-one propensity score matching, nearest neighbor one-to-eight propensity score matching, and a probit regression with matched controls. The last estimator combines nearest neighbor one-to-one propensity score matching with regression, a hybrid approach that typically generates treatment effects estimates that are more accurate and more robust to misspecification than does either matching or regression alone. In addition, we use a naïve estimator that does not control for selection bias—the simple difference between the average rates of deforestation on all titled and untitled points in our sample. The purpose is to shed light on the value of our matching approach.

For each of these estimators, we require matched points outside indigenous communities to be in the same biome as points inside. This 'exact' matching helps ensure the two sets of points are similar in terms of unobserved features that affect deforestation. For all three matching estimators we cluster standard errors at the level of the second-level administrative units (roughly the equivalent of counties in the United States) to help control for spatial correlation of errors.

The key identifying assumption for matching estimators is that conditional only on observed characteristics, non-random selection into the treatment is ignorable for purposes of measuring treatment effects. In terms of our application, the assumption is that we are able to observe and control for all important confounding factors, that is, variables that affect both the probabilities that points were included in indigenous territories and that they were deforested between 2001 and 2012. This assumption is untestable. We use Rosenbaum bounds to check for the sensitivity of our results to this type of unobserved heterogeneity. Rosenbaum bounds indicate how strongly unobserved confounding factors would need be to influence selection into the treatment in order to undermine a statistically significant ATT.

Data. Our unit of analysis is a dimensionless point defined by a latitude and longitude coordinate. For each country included in our analysis—Bolivia, Brazil, Colombia, and Ecuador—we select a sample by overlaying onto a map of the country, a rectangular 1 km sampling grid, that is, a grid with points spaced 1 km apart vertically and horizontally. We include in the sample all points where gridlines cross. We drop from the sample, all points outside of the Amazon region of each country; all points inside protected areas; and a small number of points for which data from the various GIS layers are missing.

Table 1 lists the data used in our matching analysis including the sources and units.

Table 1. Variables used in matching analysis

Variable	Description	Source	Units
Outcome			
CLEAR	Cleared during 2001-2013?	Hansen et al. (2013)	0/1
Treatment			
TITLE	Located in a native community	WRI	0/1
Control			
ALTITUDE	Elevation	Farr et a. (2007)	m
SLOPE	Slope (100*tan(π angle/180))	Farr et a. (2007)	%
NORTHFACE	Aspect = N, NW or NE	Farr et a. (2007)	0/1
CARBON	Above-ground biomass density	Saatchi et al. (2011)	mg/ha
TRAVEL TIME	Time to nearest city w/pop. >50K	Nelson (2008)	min
POPULATION	Population density	CIESIN-CIAT (2005)	person/ha
OPP. COST	Gross potential agricultural revenue	Naidoo and Iwamura (2007)	US $/ha
RAIN	Average monthly precipitation	Hijmans et al. (2005)	mm
TEMPERATURE	Average monthly temperature	Hijmans et al. (2005)	^{o}C
BIOME	Terrestrial biome (forest, grassland, etc.)	Olsen et al. (2001)	n/a
PROTECTED	Protected area	WCU-UNEP (2007)	n/a

Results. In Bolivia, Brazil and Colombia, the ATT from all three matching estimators are statistically significant at the one or five percent-levels (Table 2). In Bolivia, they range 64−68 percentage points, in Brazil, from 54−91 percentage points, and in Colombia, from 48−61 percentage points. In Ecuador, ATT estimates are less significant both statistically and economically than those for our other study countries. ATTs from two of our matching estimators are statistically significant at the five percent-level.

Table 2. Effect of titling on 2001–2013 deforestation inside native community borders: Average treatment effect on treated in percentage points, by estimator (standard error[a]) [mean standardized bias[b]] {critical value of Rosenbaum's Γ[c]}

Estimator	Bolivia	Brazil	Colombia	Ecuador
Naïve				
Unmatched controls	-73.8***	-92.3***	-91.3***	-7.3*
	[26.8]	[41.2]	[56.0]	[86.3]
Propensity score matching				
Nearest neighbor 1-1	-67.5***	-90.6***	-60.8**	-43.2**
	[4.2]	[5.3]	[4.4]	[4.4]
	{3.0}	{12.6}	{5.2}	{1.8}
Nearest neighbor 1-8	-67.3***	-90.6***	-63.8**	-40.8*
	[4.3]	[5.4]	[4.4]	[4.3]
	{3.0}	{14.4}	{8.8}	{1.4}
Probit w/matched controls	-63.7***	-53.3***	-48.2**	-33.5**
	[4.3]	[5.4]	[4.4]	[4.3]
Outcome treatment points	0.018	0.007	0.004	0.020
No. points	604,214	3,978,769	399,119	105,241
No. points treatment	90,782	1,105,080	224,450	50,954

*** p<1%, ** p<5%, * p<10%.
[a]Standard errors for propensity score matching estimators clustered at the county (municipio) level.
[b]For a given covariate, the standardized bias (SB) is the absolute value of the difference of means in the treated and matched untreated subsamples as a percentage of the square root of the average sample variance in both groups. We report the mean SB for all covariates.
[c]Critical value of odds of differential assignment to indigenous community due to unobserved factors (i.e., value above which ATT is no longer statistically significant at 10 percent-level).

Conclusion. We find that after controlling for confounding factors, titling of indigenous communities is correlated with substantially lower rates deforestation in three of our study countries: Bolivia, Brazil and Colombia. In Ecuador, the location and characteristics of indigenous communities make it difficult to draw conclusions about this correlation. We believe our results advance our understanding of the environmental effects of titling of indigenous communities in general, and of such communities in the Amazon specifically. They suggest that at least in some situations, awarding formal land titles to local communities can advance forest conservation.