

DECENTRALIZATION AND DEFORESTATION:

COMPARING LOCAL FOREST GOVERNANCE REGIMES IN LATIN AMERICA

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ABSTRACT

This research responds to an on-going public policy debate about the effects of decentralization on the environment. Specifically, we analyze why some local governance systems are more effective in maintaining a stable resource base than others. For scholars interested in national policy effects on local decision making, we suggest that it is useful to study the processes in the middle of a causal chain linking national policies with outcomes on the landscape. We argue that the effects of a policy change depend especially on the role played by local institutional arrangements.

To date, studies of decentralization have generally explored how changes in the political power of local governments shape public policy outcomes. Most of the studies to date lack longitudinal data on micro-institutional variables as well as robust outcome measures for collective goods. This study seeks to overcome such shortcomings by conducting a comparative analysis of a unique longitudinal data set on environmental decision making from 300 local governments located in three countries with varying degrees of formal decentralization: Bolivia, Guatemala, and Peru. Our general hypothesis is that strong local governance arrangements—as evidenced by local capacity for generating local tax revenues—generate positive incentives for protecting local collective goods, such as forest resources. Controlling for known drivers of forest change—such as road density and topography—we test this hypothesis in the context of Bolivia, Guatemala, and Peru.

1. INTRODUCTION

In the last three decades, most less-developed country governments have decided to decentralize at least part of their natural resource governance regimes.¹ The results have been extremely mixed. And despite the length of time that these policy experiments have been in force, there is little scientific evidence on what makes decentralized natural resource governance work.

This paper responds to an on-going public policy about the contextual conditions that affect the effectiveness of decentralization policy (Bardhan and Mockerjee, 2004; Treisman, 2007). Here we develop an argument about how decentralization affects decision making about the environment as well as the environment itself. More specifically we address the question as to how local governance institutions respond to decentralization and what effect does this response have on the stability of the resource base.

To address this question, we employ a four-pronged strategy. First, we frame the issue of decentralization from a new institutionalist perspective and develop a testable hypothesis on the environmental effects of decentralization. Second, we utilize a comparative research design that exploits the variation in institutional conditions both within and across national policy regimes. Our unit of analysis is the local government and we study a random sample of 300 local government territories in three different national regimes with varying degrees of decentralization: one highly decentralized (Guatemala), one highly centralized (Peru), and one semi-decentralized (Bolivia). Third, we utilize comparable, time-series observations on a wide array of variables related to resource governance and environmental outcomes for all 300 municipal territories. We use remote sensing technology to create time-series observations of forest cover for our sampled municipalities for three different dates. Finally, we employ

¹ Drawing on Rondinelli et al, (1989), we define decentralization as the devolution by central (i.e. national) government of specific functions, with all of the administrative, political and economic attributes that these entail, to local (i.e. municipal) governments which are independent of the center and sovereign within a legally delimited geographic and functional domain.

robust regression techniques to test the hypothesis and interpret the results of those tests.

This paper has eight sections. The next one provides a background to the evolution of modern forestry policy in the developing world. In section three, we review the core findings in the decentralization literature related to forest governance. Section four outlines our approach to the study of decentralized governance, followed by a description of our data and methods. In section six we present our results, and provide a discussion of the causal story in section seven. We offer our conclusions in section eight.

2. THE EVOLUTION OF FOREST POLICY

Until the 1970s, central governments in most countries viewed the governance of forests through the lens of economic development (Arnold 1992, 1998, Wunsch & Olowu, 1990). While forests could be managed either by the state or private entities, the value of forest protection was determined by the value of their stock and flow to the market. If the market considered the land underneath the trees to be more valuable than the wood, governments generally did not stand in the way of forest clearing (Richards & Tucker 1988). This orientation also found its way into foreign aid programs: industrialized countries promoted the scientific, professional management of forest resources to meet economic goals of less-developed country governments. Large, single-species timber plantations were the policy prescription of the day.

The last 30 years has seen significant shifts in ideas about forests and their governance. New views about the role of forests in larger ecosystems put goals other than natural resource capitalization on central governments' agendas. The failure of many top-down forest policies also motivated a reexamination about where best to place the political authority over forests. Decentralization has emerged as an key component to ideas about effective public policy, democracy, and the environment. International donors and multilateral lending agencies (e.g., InterAmerican Development Bank 1994, OECD 1997, World Bank 1988, 1997; FAO, 2001), now fund scores of projects incorporating decentralization as part of their goals. By the late 1990s a World Bank survey found that 85 percent of the world's less-developed

countries had embarked on processes towards increased decentralization of their public sectors (Bahl 1999). Whether discussed in the context of formal federal structures or the informal rules of rural communities, many books and articles laud the positive effects of decentralized governance, although a growing group of scholars are beginning to express their skepticism towards decentralization as a policy reform panacea (e.g. Agrawal & Ostrom, 2001, Andersson, 2002; Smoke, 2003; Platteau, 2004).

According to proponents of decentralization, making lower-level officials responsible for the provision of more goods and services should result in more efficient, flexible, equitable, accountable, and participatory government (Oates 1972, World Bank 1988, Rivlin 1992, Chubb 1985, Feldstein 1975, Maro 1990, De Tocqueville [1835] 1945, Dahl 1981, Bish & Ostrom 1973, Inman & Rubinfeld 1996, Ferejohn & Weingast 1992, Crook & Manor 1998, Blair 2000). Unlike national-level agencies, the argument goes, local politicians and officials will design more appropriate policies because they are more familiar with their environments and the citizens' needs.

Policymakers, donors, and scholars long frustrated by the lackluster outcomes of centralized environmental policy in developing countries increasingly advocate the marriage of natural resource governance and decentralization. Hoping to harness local knowledge for better environmental protection, environmentalists have sought to make municipal governments responsible for protecting environmental resources: forests are one of the principle targets of their efforts (FAO 1999, 2001; WRI, 2002). Latin America, which hosts about two-thirds of the world's remaining rainforest (UNEP, 2001) is certainly no exception. Most of the region's countries have already transferred an increasing number of central-government duties related to forest governance to lower levels of government, most commonly to the municipality. Throughout the region, both donors and national governments have put their hopes to such reforms to increase the public sector performance in forestry. Within Latin America, no other countries have taken the decentralization reforms of their forestry sectors further than Guatemala and Bolivia (FAO 1999; 2001; 2003).

In Guatemala, where forestry decentralization is extensive, municipal governments can issue and tax logging permits on any type of forestry property (private, public, or municipal) for up to ten cubic meter of timber per household and year. The municipality can also own forest property, and create and enforce its own management rules within it as long as these rules

comply with the national forestry law. Municipal governments can also rent out part of their forest to local citizens and charge user fees for services provided. In addition to the revenue raised by the municipalities themselves, municipal governments receive 50 percent of the centrally collected timber harvesting taxes (although most municipalities still receive very small amounts). Guatemala fits the criteria for a highly decentralized case.

In Bolivia, where forestry decentralization is limited the authority of the municipal governments is largely limited to performing the tasks that the central government asks of them. Bolivia fits the criteria for a semi-decentralized case. According to Ribot (2002), this form of decentralization is now the most common natural resource policy in less-developed countries. In Bolivia's forestry sector, the role of the municipal government is to assist the central government in promoting sustainable forest management among local users as well as monitoring and enforcing the centrally defined rules. Bolivian municipalities also receive intragovernmental transfers but, like Guatemala, the official sums are not significant to most. The central government owns all forest resources in the country, including trees on individual private property.

In Peru, there is no decentralization of forest governance responsibilities to local governments, and as such it fits our criteria for a "pre-decentralization" baseline case in our comparative research design. In contrast to the relatively decentralized forest governance structures of Bolivia and Guatemala, Peru's central government has resisted pressures from both donors and several groups of local governments to decentralize the responsibilities related to forest governance (Soria, 2003; ITTO, 2004; Government of Peru, 1975, 2001).

The new experiments in decentralized forest governance policy in Latin American are receiving increased attention from policy analysts and scholars. Next we review this growing body of literature and their core hypotheses.

3. PREVIOUS RESEARCH

While theoretical thrusts, geographical areas, and thematic foci vary a great deal across studies in the decentralization literature, many studies arrive at similar findings. These are, what we might call, the core hypotheses of the decentralization literature. First, most studies agree that positive outcomes in decentralized environmental governance are unlikely in the absence of popular participation in local government decision making (e.g., Singleton, 1998; Blair, 2000; Larson, 2002). One of the basic premises for successful decentralized governance is the relative superior cost-effectiveness of local vis-à-vis central authorities to incorporate local information of time and place into public policies. Such improvements are not likely to materialize, however, unless resource users are allowed a seat at the table where decisions are made in the local jurisdiction. Moreover, such participation has little meaning unless the local government is authorized to make decisions regarding the existing rules for resource use, an attribute that is not always part of the local mandate (Andersson & Laerhoven, 2007; Agrawal & Ribot, 1999; Agrawal & Ostrom, 2001).

Second, most researchers now agree that positive outcomes in a decentralized environmental governance framework rely on local governments being downwardly accountable to resource users. (e.g., Crook & Manor, 1998; Smoke, 2003; Ribot, 2002). These mechanisms provide essential checks and balances between the different governance actors involved in the public policy process, and perhaps most importantly, make it possible for resource users to hold officials responsible for their actions. While democratic elections of local officials seem to be a necessary condition for this to occur, they are hardly sufficient. Scholars are finding that traditional and informal social networks characterized by severe power asymmetries and patronage relationships often trump the formal structures of democratic elections and hamper any real democratic decentralized governance of natural resources (Andersson, 2002; Platteau, 2004).

Third, one of the most universally accepted findings is that successful decentralized governance of natural resources rely on the technical capacity of the local unit to which governance responsibilities have been devolved (e.g., Andersson, 2004; World Bank, 1988, Pacheco, 2000; Flores & Ridder, 2000; Contreras & Vargas, 2001). Even if local governments are downwardly

accountable and include users in decision making, such efforts are not likely to lead to positive outcomes unless the governance system is capable of generating appropriate technical responses to the observed problems. For example, what are the most appropriate forest management options for local forest users, or what species seem most adequate for soil conservation and watershed management? If there is no local technical expertise the actions taken may not solve the problem.

Fourth, essentially all studies now agree that without a secure source of funding, there is little local governments can do about environmental issues (e.g., Fiszbein, 1997; de Mello, 2000; Kaimowitz et al, 2000; Pacheco, 2000). Money is needed to hire professional staff, and to equip and train professionals so that they carry out their activities. Despite the widely recognized need for financial resources, most local governments in decentralized regimes in developing countries have a largely under-funded mandate (Gibson, 1999; Boone, 2003; Andersson et al, 2004, 2006).

These core contributions to the decentralized literature share three important limitations that this study seeks to address. First, while many of these studies consider how local variations in institutional arrangements affect the performance of the local governments, (i.e. Crook & Manor, 1998; Pacheco, 2000; Larson, 2002; Agrawal & Ribot, 1999), most extant studies are case studies that focus on a very small sample of local units within a single country or subnational region. While such qualitative studies are very valuable in terms of the rich details they provide on how local actors perceive the new decentralized policy, they do not provide generalizable findings on the broader effects of decentralization. Second, many of the existing studies do not use measures of governance outcomes as their dependent variables. Instead they use proxy measures—such as participation and public resource allocations—which may, or may not, be linked systematically to environmental outcomes, (e.g. Blair, 2000; Fiszbein, 1996. Pacheco 2000; Larson, 2002). Finally, no study in this area that we are aware of has used longitudinal data to analyze the environmental effects of decentralization. We believe the current lack of scientific evidence concerning the environmental effects of decentralization is largely due to these three limitations.

4. OUR APPROACH

Policy reforms, such as decentralization, do not automatically translate into environmental outcomes. It is therefore crucial to analyze the processes in the middle of a causal chain linking policies with outcomes. We argue that the effects of a policy change depend especially on the role played by local institutional arrangements. Our proposed research focuses on the institutional arrangements and incentives of local governance actors—local politicians in particular—to explain their decisions and actions as well as the resultant outcomes for forests.

Our approach builds on the work of the new institutionalism school of political economy (North 1990, Ostrom, 1990; Knight 1992, Horn 1995, Bates 1998). New institutionalists seek to explain political behavior by examining the constraints imposed upon individuals by institutions. Our approach emphasizes the value of considering institutions at multiple levels, drawing on earlier work that analyzes institutions as “two-level games” (Putnam 1994), “nested action arenas” (Ostrom 2005), or systems of multi-level governance (Hooghe & Marx 2003). We recognize that institutional arrangements are nearly always made up of several layers of social orders—from local micro-interactional orders to international and transnational arrangements—and that the relationships of complementarity and contradiction between these layers are crucial.

We use these insights to build a model for the analysis of decentralized resource governance. Through this approach, we highlight the ways in which decentralization reforms are *filtered* by institutional arrangements to produce outcomes visible on the landscape. The key point in our approach is that the configuration of local institutional arrangements shape the extent to which decentralization affects the environment. We also recognize that to assess the influence of decentralization reforms on policy outcomes, it is necessary to go beyond traditional measures of formal decentralization—measures that simply treat decentralization as a dichotomous variable and assigns a value of 0 if the government of a country has not passed any formal decentralization reforms, and a value of 1 if it has. Here, we measure the

extent to which local governance actors have taken actions related to service provision into their own hands, regardless of what the formal mandate says. This is arguably a more accurate and context-sensitive measure of decentralization.

Our general hypothesis is that *the stronger the decentralized institutions for local tax revenue generation, the stronger the incentives for forest conservation*. We posit that local institutional arrangements are what gives meaning to decentralized governance. Unless local actors actively create institutional arrangements that can effectively handle the challenges of providing and producing public services to the electorate, decentralization has little meaning, and the ability to collect revenue from local sources is a strong proxy for local institutional capacity. Hence, to understand the effects of decentralization we need to study the local logic of organizing governance arrangements.

For example, a local government that has an official mandate on paper, but does not translate its mandate into real actions on the ground is arguably not a decentralized antiquity in practice. On the other hand, a local government in a centralized governance structure that is nevertheless taking actions into its own hands and organizes local tax revenue collection, is a de facto decentralized entity. We argue that analysts would learn more from paying attention to and measuring what governance actors actually do rather than what the government says they are supposed to do.

To test this hypothesis in the context of Bolivia, Guatemala, and Peru, we have constructed proxy measures for de facto and de jure decentralization, which are described in tables 1 and 2 and in the narrative of the next section.

5. DATA AND METHODS

To test the study's main hypotheses, we rely on a comparative research design as well as a substantial effort to collect longitudinal data through survey work in the 300 selected municipal territories, as well as

the interpretation of satellite images of forest cover for each unit of analysis: the municipal territory.

Bolivia, Guatemala, and Peru are ideal cases for a comparative study of decentralized forest governance. While they share a number of essential biophysical, socio-economic, historical and cultural characteristics, they also differ on the variable of theoretical interest to this study: decentralization. All three countries are Latin American, mid-level developing countries with large rural and indigenous populations, significant forest cover, frequent land use-related disputes, and locally elected mayors. But the three countries differ a great deal when it comes to the degree of decentralized governance structure in each country's forestry sector. The amount of regulatory power that each national government grants to its local governments fits along a continuum between a great deal of local decision making autonomy (Guatemala), to moderate amounts (Bolivia), to virtually no local decision-making power in the forestry sector (Peru).

There are three major data sources for this study: (1) surveys of local governance actors (2000 and 2007), (2) census/archive data (2000, 2007), and (3) satellite images (1993, 2000, and 2007). In each of the 300 selected municipalities, we interviewed the elected mayor who held office in 2000 and 2007. Each face-to-face interview took approximately 1.5-2 hours. The survey instrument (258 questions) was designed to elicit information regarding the interviewee's policy priorities, staff, relationship with central and nongovernmental agencies, and relationship with citizens. It uses a variety of techniques to understand political incentives and behaviors. We checked several of the interview responses with archival data and found the survey instrument to be highly reliable

In addition, we use government statistics from the three countries and topographic data created using digital elevation models as well as forest cover data that were generated using remote sensing techniques (Landsat TM imagery).

[Tables 1 and 2 about here]

The dependent variable we use here is the percent forest cover for each municipality at the time when the surveys were carried out.

These data are available for 1990, 2000, and 2006 in Peru, 1991, 2001, and 2006 in Guatemala, and 1993, 2000, and 2007 in Bolivia.

The main independent variables of interest are the proxies for *de facto* and *de jure* decentralization. We test the effects of these two variables on measures of forest conditions. Descriptions of all variables used in the analysis are in table 1, and summary statistics are shown in table 2

The road density data which we use here as a control was only available for one time period in all three countries. Therefore, the 2001 road density data was used as a proxy for road density in 2007 as well.

To test the effects of *de facto* and *de jure* decentralization on forest conditions, we use extradispersed poisson regression. This estimation technique is appropriate for our data since our dependent variable is a proportion which cannot be transformed to normality because of a large number of zeros and the mean and variance are not identical (Hoffman 2004; Rabe-Hesketh and Skrondal 2008). Finally, to address the autocorrelation problems inherent in the use of panel data, we use a lagged dependent variable—forest cover for the date prior to the first survey wave (Frees, 2004; Rabe-Hesketh and Skrondal, 2008).

We also test the effects of *de facto* and *de jure* decentralization on mayors', community leaders', and forestry officials' assessment of the importance of forestry as a policy priority, compared to other policy areas. Because this variable follows a normal distribution, we use GEE (generalized estimating equation) cross-sectional, time-series regression with unstructured intra-unit correlation assumptions, where intra-unit correlations on the dependent variable are derived from the data and standard errors are adjusted accordingly. We also test these two models with several other estimation techniques, reported in the appendix.

6. RESULTS

The multivariate regression results, presented in Table 3, provide support for the hypothesis that the strength of local institutions for taxation is positively associated with forest conservation. It appears that

municipalities that have more financial autonomy experience less forest loss and invest relatively more in forestry activities. Another key finding is that de jure decentralization seems to have a very different effect on forest outcomes compared to de facto decentralization: de jure decentralization appear to have an inconsistent effect on outcomes (and the significance of the de jure variable are also less robust, as reported in the appendix).

The model results are consistent with previous research that have found road density, NGO pressure, the local financial importance of forestry, and topography to affect forest change. By including variables for road density and slope, we control for each municipal territory's propensity for being targets for profitable conversions from forests to agriculture, a major driver of deforestation in tropical countries. The slope variable, which measures the proportion of land that is not feasible for industrial agriculture because it is steeper than the conventional 12 percent threshold, is positively correlated with forest governance investments ($p < 0.05$), but has no statistically significant effect on forest cover (model 1).

[Table 3 about here]

The results from these multivariate regression models provides evidence that de facto decentralization matters for forest conservation in these three countries. Our de facto decentralization variable is a measure of how local governance actors respond to the opportunities offered to them through the decentralization reforms. A municipality that organizes itself to raise its own revenue is less dependent on external sources and thus enjoys more autonomy. This we see as an important proxy for local institutional capacity.

According to the regression results, the *de facto* decentralization variable has a positive and statistically significant effect on forest cover ($p < 0.001$) and on forest governance investments ($p < 0.01$). Taken together, these results suggest that when local actors have the capacity to gather revenue, they are also more likely to be able to implement effective forest conservation policy. We return to the interpretation of this finding in the discussion section below.

[Figure 1 about here]

Figure 1 displays the magnitude of the effect *de facto* decentralization has on forest cover in our sample. As the importance of local sources of income increases from “none” to “much more important than other sources,” the predicted percentage of forest cover increases from about 15 percent to more than 35 percent. These predicted values assume that all other variables are held constant at their mean.

7. DISCUSSION

The results of the regression analysis raises an important question that merits further discussion. The question is this: Why would strong local capacity to raise taxes produce better forest outcomes? The problem that we confront is that even if it is true that the local capacity for taxation reflects the local capacity for implementing locally defined policies, it does not necessarily mean that protecting forests will be the priority goal for the local governance actors. If a municipality has the goal of expanding agriculture or cattle raising activities, for example, these land uses compete with forestry and it would be difficult to achieve a simultaneous expansion of all of these competing land uses. An expansion of agriculture tend to impinge on forest cover, and vice-versa.

The challenge is for the analysis of *de facto* decentralization to account for pressures on the forest resource from alternative land uses. We address this concern by introducing control variables for slope and road density in the models. These variables are good proxies for forest conversion to agricultural and pasture lands, which means that the effect of the *de facto* decentralization variable takes into account the feasibility of land cover conversion from forest to competing land uses. In fact when we drop these control variables, the effect of the *de facto* decentralization variable loses some of its statistical explanatory power in both models.

The second thing our analysis does to discern the effect of *de facto* decentralization on forest conditions is to examine the influence of this variable on a more intermediate outcome variable, which would

provide a plausible causal path between local taxation capacity and forest cover. The intermediate outcome variable is the dependent variable in model 2: importance of forestry as a policy priority. The effect of de facto decentralization on this outcome variable is positive and statistically significant ($p < 0.01$). This result points to a plausible link between stronger local capacity to raise taxes and more stable forest cover because stronger taxing capacity is associated with greater emphasis on forestry policy.

The fact that our de facto decentralization variable positively affects the priority of forestry activities would suggest that municipalities that are better at raising their own revenues are also more interested in investing in forestry, *but only when controlling for the propensity to convert forests to other land uses*. This provides a possible explanation to the positive effects of the de facto decentralization variable on forest cover stability (model 1).

In sum, it must be stressed that the positive effect of de facto decentralization is contingent on this particular model specification—especially the presence of controls, such as road density and steep slope, which measure the propensity for forest-to-agriculture conversions. Hence what we see is the effect of a variable under very constrained contextual specifications: municipalities with high capacity to tax are more effective in all that they do and when controlling for the profitability of investing in non-forestry activities, we see a higher likelihood of forest conservation.

8. CONCLUSIONS

The study provides empirical tests on the extent to which decentralization has any discernable effects on local forest outcomes. Because of the comparative research design, comparable data on local institutions and forest conditions across all three countries, as well as rigorous analytical methods, we are in a position to assess the effects of decentralization policies, its local governance responses and how these

things affect the environmental outcomes on the ground. We see no systematic effect of de jure decentralization in these three countries, but find some support for the hypothesis that de facto decentralization can make a difference under some circumstances.

One of the main contributions of the study is the introduction of a nuanced measure of decentralization—the local ability to raise their own public revenue. The use of this measure in the analysis is more informative of the role played by local governments in shaping public policy outcomes, such as forest governance investments and forest cover stability.

This research is of potential practical value to donors and governments around the world who grapple with the challenge to create policies that effectively govern forest resources and other common pool resources. This is particularly true in the context of the new international program called Reduced Emissions from Deforestation and Forest Degradation (or REDD), which promises millions of dollars in incentives to developing countries that manage to reduce their current deforestation rates. What this analysis shows is that local governments have an important role to play in efforts to protect forests and that it would be a mistake to centralize decision making about forest conservation efforts. It also shows that constraining local governments' ability to raise their own taxes and service fees may be counter-productive to local empowerment and responsible local governance.

Finally, the analytical results about the positive effects of de facto decentralization on forest outcomes raises new questions for future studies in this area. While we provide our own interpretation of the causal process that allows municipalities with stronger capacity to raise their own public revenues to also be more effective in protecting their forests, these interpretations are largely speculative in nature. Future research is needed to test the plausible causal paths more rigorously.

APPENDIX 1 (FOR POSSIBLE ON-LINE SUPPLEMENT)

Here, we present several checks on the robustness of our results. In general, we find that the results presented above are not sensitive to specification, the presence of high-influence cases, or the nature of the sample used, with a few notable exceptions that we will describe below. Our de facto decentralization variable is much more robust than the de jure decentralization variable, though it is difficult to determine whether this is simply because of much less variation on the de jure variable or because the relationship is weaker or due to chance.

FOREST COVER MODEL

We use extradispersed poisson regression for the models presented in the text because scholars have cautioned against the use of many standard robustness checks on negative binomial regression models on the grounds that they are not true generalized linear models (Hoffman 2004), however, we also tested the results presented in the text using negative binomial regression models, with no difference in the significance or direction of the effects of our independent variables of interest (de facto and de jure decentralization).

First, we tested our sample for robustness to the exclusion of high-influence cases by excluding cases with high deviance residual values, high Pierce and Schafer adjusted deviance values, high Anscombe residual values, and high Pearson residual values. When these cases were excluded, our the direction and significance of our results for de facto and de jure decentralization did not change, except that in several cases, the results became more significant. With each of the sets of deviance statistics, we excluded cases with values above 10, 9, 8, and 5, and below -10, -9, -8, -5.

Second, we tested our residuals for normality, using a normal probability plot. None of the deviance statistics we used (deviance residuals, Pierce and Schafer adjusted deviance residuals, Anscome residuals, and Pearson residuals) deviated substantially from normal, although the Pearson deviance values showed more systematic deviation than we were comfortable with. Therefore, we re-tested the model using a negative binomial regression model with heteroskedasticity-robust standard

errors, and found no direction in the significance or direction of the decentralization variables.

Third, we performed a series of sensitivity tests, in which we removed sets of control variables one by one to see if the decentralization variables maintained their direction and significance. We removed the following sets in turn: institutional incentives variables (community organization pressures, central government supervision, and NGO pressures), the Bolivia dummy, the education variable, the budget variable, and the geophysical controls (lagged forest cover, road density, and slope variable). The de jure decentralization variable was sensitive to the removal of the Bolivia dummy and geophysical controls, but the de facto decentralization variable was robust throughout.

Finally, we split the sample in several different ways and re-tested our model. We found that the results did not change if we divided the sample using the de facto decentralization variable at several different values—both de facto and de jure decentralization variables remained significant in the expected direction. If we dropped the non-decentralized cases, results also were unchanged. If we dropped the decentralized cases, both variables became insignificant, but this is unsurprising, giving the low number of remaining cases (30). We also split the sample by population density, finding that our results were not sensitive to the exclusion of high or low population density cases, except where the number of observations was reduced below approximately 150, in which case both decentralization variables sometimes became insignificant. We also found that our independent variables of interest were robust to the exclusion of both high-income and low-income cases until our n dipped below about 150.

IMPORTANCE OF FORESTRY

We used a similar series of tests on the model we present above which uses “the relative importance of forestry as a policy priority” as a dependent variable. In general, we found that the de facto decentralization variable was quite robust, though the de jure variable was less so.

First, because we are using a population-average (GEE) model, we re-test the model with a number of intra-unit correlation structures, including

exchangeable, unstructured, independent and ar-1 structures. Our results did not vary in direction or significance.

Second, we followed a similar procedure to that described above, excluding observations with high deviance residual values to see if our model was robust to the exclusion of outliers, using cutoffs of .2 and .4. We found that the de facto variable was robust to the exclusion of outliers, though the de jure variable became insignificant when outliers were excluded at the .2 cutoff.

Third, we examined the normality of our errors using a normal probability plot. We found that our residuals did seem to diverge systematically from normality, so we tested the model with heteroskedasticity-robust standard errors, with no difference in the direction or significance of our results.

Fourth, we tested the sensitivity of our model to the exclusion of different sets of variables, following the same procedure described above. We found that both decentralization variables were robust to the exclusion of control variables, except for the biophysical controls. We do not believe that this weakens our findings, as these controls are particularly important in reducing bias of our estimates; excluding them simply introduces bias into the results. On the other hand, exclusion of less important control variables has no effect.

Finally, we split out sample in several different ways, to see if the reported results are sensitive to the particular population used. In general, we found that the de facto decentralization variable was robust to these tests, though the de jure variable often became insignificant. We divided the sample, for example, by country (with similar results to those reported above), by forest cover, de facto and de jure decentralization, and municipal budget size.

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TABLES AND FIGURES

Table 1: Variable Descriptions

| Variable | Description and Source |
|--|--|
| Forest cover (pct.) | Percent of municipal area covered with forest. Remote sensing data. |
| Relative importance of forestry as a policy priority | Compared to other policy areas, the importance of forestry as a policy priority, averaged across responses by mayors, forestry officials, and community leaders within each community. |
| Forest cover (lagged) | Forest cover from the previous period (2000/2001 or 1990/1991) |
| De facto decentralization | The importance of local sources of income. Responses range from 0 (“none”) to 5 (“much more important “ than other sources). |
| Community pressure | The frequency of community organization demands for forestry-related services. Ranges from 1 (“much less frequent” than demands for other types of services) to 5 (“much more frequent”) |
| NGO pressure | The frequency of non-governmental organization demands for forestry-related services. Ranges from 1 (“much less frequent” than demands for other types of services) to 5 (“much more frequent”) |
| De jure decentralization | Whether the municipality is in a regime which is formally decentralized in the forestry policy area. 0 for Peru during 2001 and 1 for Guatemala and Bolivia, and Peru during 2008. |
| Frequency of central government supervision | The frequency with which central government representatives/agents supervised forestry activity in each municipality, ranges from 0 (never) to 5 (very frequently) |
| Elite education | The average level of education of elites surveyed in each municipality, in years of education. Elites surveyed included mayors (2001 survey wave); mayors, forestry officials, and community leaders (Bolivia 2008 wave); mayors, forestry officials, community leaders, and municipal treasurers (Guatemala 2008 wave); and mayors and community leaders (Peru 2008 wave) |
| Budget size (USD millions) | Size of municipal budgets, in millions of US dollars. Gathered in 2008 survey wave in Peru and Guatemala; 2001 data and 2008 data in Bolivia |
| Road density (logged) | Kilometers of road per square kilometer. Derived using remote sensing data. Unfortunately, road coverage data was only available for 2001 in Guatemala, where we used the 2001 data as a proxy for 2008 road coverage. |
| Pct. of slope > 12% | Percent of municipal surface area where land slope is greater than 12% (the level below which mechanized sugar cane production is feasible). These variables were derived from digital terrain models of Peru, Bolivia, and Guatemala. |
| Bolivia | 1 if municipality is in Bolivia, 0 otherwise. |

Table 2: Descriptive Statistics

| Variable | Obs | Mean | Std Dev | Min | Max |
|--|------------|-------------|----------------|------------|------------|
| Relative importance of forestry | 525 | -.69 | 1.12 | -4 | 2.1 |
| Forest cover (pct.) | 475 | 24.39 | 24.09 | 0 | 100 |
| Annual forest change (pct.) | 441 | 0.01 | 0.19 | -0.93 | 3.19 |
| De facto decentralization | 574 | 2.42 | 1.13 | 0 | 5 |
| Community pressure | 620 | 2.87 | 1.19 | 1 | 5 |
| NGO pressure | 525 | 2.24 | 1.3 | 1 | 5 |
| De jure decentralization | 675 | 0.67 | 0.47 | 0 | 1 |
| Importance of forestry to municipal budget | 616 | 1.92 | 1.19 | 1 | 5 |
| Elite education | 628 | 11.47 | 3.45 | 0 | 18 |
| Muni. Budget (Thousands of US Dollars) | 611 | 17.6 | 88 | 0 | 1847.7 |
| Road density (logged) | 445 | -0.24 | 2.84 | -9.21 | 3.43 |
| Pct. of slope > 12% | 663 | 47.06 | 30.21 | 0 | 94.8 |
| Bolivia | 648 | .34 | .47 | 0 | 1 |
| Forest cover (lagged, pct.) | 468 | 23.08 | 25.34 | 0 | 100 |

| Table 3: Regression Models With All Controls | | |
|--|--|---|
| Dependent variable | Forest cover (pct.) | Relative importance of forestry policy |
| Model | Extradispersed poisson regression (square root of dispersion adjustment) | Population-averaged panel regression with unstructured correlation assumption |
| De jure decentralization | 1.104 (0.002)** | -0.645 (0.034)* |
| De facto decentralization | 0.166 (0.000)*** | 0.125 (0.005)** |
| Community pressure | 0.040 (0.376) | 0.224 (0.000)** |
| Frequency of central government supervision | 0.046 (0.162) | 0.044 (0.200) |
| NGO pressure | 0.090 (0.015)* | 0.093 (0.016)* |
| Bolivia | -0.872 (0.000)** | -0.309 (0.221) |
| Elite education | 0.010 (0.431) | 0.003 (0.796) |
| Muni. budget (Thousands of \$US) | -0.000 (0.420) | -0.000 (0.877) |
| Road density (logged) | -0.194 (0.000)** | -0.026 (0.565) |
| Slope above 12% (pct.) | -0.002 (0.122) | 0.003 (0.045)* |
| Forest cover (lagged, pct.) | 0.004 (0.022)* | |
| Forest cover (pct.) | | 0.010 (0.000)** |
| Constant | 1.557 (0.000)** | -1.629 (0.000)** |
| Observations | 375 | 376 |
| Municipalities | 217 | 218 |
| p values in parentheses + significant at 10%; * significant at 5%; ** significant at 1% | | |

Figure 1: The effect of de facto decentralization on forest cover

