Economic Development and Forest Conservation in Decentralized Governance*

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Abstract

In the face of depleting natural resources, governments in the developing countries face the task of balancing economic development with conservation efforts. We study how governance structure surrounding environmental policy-making shapes this trade-off by examining the economic projects in India that required diversion of forest land and were submitted to the Indian government for approval. Using the universe of proposals submitted between 1990-2009 and their application outcomes, we exploit a policy reform that changed the approval authority for a certain size of projects from the Central to State governments. We find that switching the approving authority significantly *reduced* the probability of approving development projects, but *increased* the number of applied projects. Estimates from a structural model with endogenous applications and approvals indicates that State governments (as compared to the Center) put a 6% *lower* weight on economic development (vis-a-vis forest conservation), and also have 11% *lower* application costs. This results in a lower quality of new projects that are proposed and approved on average, significantly attenuating the overall positive effect on conservation. Taken together, we conclude that decentralization leads to a modestly adverse impact on forest conservation while approving lower quality development work.

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1 INTRODUCTION

With growing concerns surrounding natural resource depletion and associated climate change,[1] governments across the world face the task of balancing economic development with environmental conservation. This trade-off is particularly stark for many low and middle-income countries, who are vulnerable to climate change and yet aspire to catch up with the developed world. The governance structure surrounding the extraction and usage of natural resources is therefore of specific significance in these countries, since these institutional frameworks shape the incentives and behavior of all stakeholders, which ultimately determines the trajectory along which these trade-offs are resolved.

In this paper, we shed light on understanding this trade-off by examining the effect of a governance reform in India that expanded the scope of decentralized policy-making in the context of converting forest land for economic development projects. To elaborate on the context, any economic activity requiring diversion of forest land in India needs the approval of either Central or State governments, depending on the size of land to be diverted. This implies that a government gets to directly shape the development-conservation trade-off. However, if the two types of government weigh economic development differently vis-a-vis conservation, then decentralization could differentially impact the overall level of both forest conservation and economic progress. As a consequence, it could further affect the type (or quality) of projects that are proposed to, and approved by these government bodies, which could either exacerbate or attenuate the overall impact on economic development.

Several studies in the literature have examined the impact of decentralization on environmental policy-making.[2] However, they have focused on contexts where any form of resource extraction (deforestation or water pollution for example) is either illegal or undesired, providing a clear objective for the government to reduce it. In contrast, our context focuses on the *legal* deforestation for the purposes of legitimate economic activity and thereby, provides us with a unique opportunity to examine how decentralization of this decision can shed light on understanding how governments trade-off environmental conservation with economic development and its consequences on the quality of projects that are proposed and approved.

To examine this question, we compile a rich administrative dataset in India that consists of the universe of proposals submitted to the Indian government for diversion of forest land for economic projects during the period 1990-2009. Spanning a period of two decades, these data contain detailed information on the location and parcel size of the forest land to be diverted, along with its intended economic use, and most importantly, the approval outcome of each project (along with other details). Historically, the approval decisions on smaller projects with an area of up to 20 Hectares were made by State governments, while the Central government assessed larger projects. We exploit a unique policy experiment in 2004 that doubled this size threshold to 40 Hectares, thus increasing the share of projects assessed by State governments (from 48% to 66%).

Using this policy reform, we begin our analysis by using various empirical methods to establish three key empirical facts on the impact of this policy on the application and approval of projects. First, we find a discontinuously higher density of projects that are proposed just below 20 Ha. in the pre-period. On

[1] See Lawrence and Vandecar (2015), Konikow and Kendy (2005), Shukla, Nobre, and Sellers (1990) for examples.

[2] For example, see Burgess, Hansen, Olken, Potapov, and Sieber (2012) on illegal deforestation in Indonesia, Lipscomb and Mobarak (2016) on water pollution in Brazil, Edmonds (2002) and Somanathan, Prabhakar, and Mehta (2009) on forest conservation in Nepal and India respectively.

the contrary, while there is no such discontinuity at 40 Ha. in the pre-period, there is an excess density right below the 40 Ha. threshold in the post-period, when the threshold also moved to 40 Ha. This implies that applicants prefer to apply to State governments over the Center, suggesting either a higher probability of approval or a lower cost of application (or both) under State governments.

Second, using a difference-in-differences specification, we find that the average approval probability of the projects affected by this reform (between 20-40 Ha.) *falls* after the reform. Taken together with the first fact, this suggests that both the approval probability (or preference for development projects) and application cost are likely lower for the state government.[3]

Lastly, we find that approval probability as a function of size does not exhibit any discontinuity at 20 Ha. in the pre period, but is actually *higher* to the left of the the 40 Ha. threshold in the post-period. At a first glance, this may seem inconsistent with the previous observations. However (as we will elaborate later) the key mechanism to reconcile these effects is to take into account not only the "selection" of projects i.e., the volume and quality of applications, but also the "sorting" of projects across the thresholds. Intuitively, if sorting is costly, only high quality projects around the threshold sort to the left, increasing the average quality (and hence the average approval probability) of projects to the the left of the threshold, while reducing it to the right.

The above empirical facts indicate that decentralization changes both the selection of projects that are applied, as well as their sorting around the threshold. To examine these issues more rigorously, we develop a theoretical framework that endogenously models the decision of a government to approve projects, and hence the set of projects that are applied. We initially abstract away from any sorting issue and focus on the selection problem. This is because while sorting would be limited to the neighborhood of the threshold, the selection effect is a more general concern in this context. We later augment our model to allow for sorting to estimate its relative importance compared to selection in explaining the empirical distribution of project size. Our analysis unpacks several forces that are at play in this context to identify the parameters of interest. First, we point out that since applying for approval is costly, applications are endogenous. The decision to apply depends on the likelihood of approval and cost of application, and for a given project, both of them could be different under the two types of government. The approval probability for the same project could be different across center and state due to the differential preference weights on project value in their payoff functions. Additionally, cost of application could be different, if, for example, an applicant is more likely to have connections with officials in the state government than the center, or vice versa. The empirical difference in average approval probabilities across central and state governments, therefore, may not reveal the state government's relative weight on project value, since the average (unobservable) quality of projects applied under the two types of government could be different.

Under parametric assumptions on the nature of these idiosyncratic preference shocks for the government, and the underlying distribution of project quality, we are able to identify, for each project size, the threshold quality level above which projects apply (under each type of government). This in turn determines the average approval probability as a function of the size of the project. The policy reform in 2004 allows us to empirically observe the empirical distribution of applications and their average prob-

[3] It is possible for states governments with higher preference for projects and lower application cost to also generate the two facts, but in that case, the application cost would have to be significantly lower to justify a fall in the average approval probability. In such a case, the mass of applications would have to increase substantially, something we do not observe, making the possibility an unlikely one. Our structural estimates confirm this intuition subsequently.

ability for each project size between 20-40 Ha. under both the Centre (in the pre-period) and State (in the post-period). These moments map directly to the model, thus allowing us to identify key structural parameters. In particular, we recover the weight that the State governments put, relative to the Centre, on the economic value of projects vis-a-vis conservation, and the relative cost of application under the State government relative to the Centre. We find, somewhat surprisingly, that State governments put 6% lower weight on the project value relative to the Centre, reducing their average approval probability by 10%. This implies they care more about conservation than the Center. However, we find that the application costs for State governments are also 11% lower as compared to the Center, which increases the mass of applications under State governments by 18%. This leads to an overall adverse effect on conservation by about 8%, indicating that the state's greater weight on conservation gets overwhelmed by the endogenous increase in lower quality projects that get approved. Taken together, our results imply that the average quality of approved projects falls due to adverse selection driven by lower cost of application and hence decentralization leads to lower conservation, while approving lower quality of economic projects.

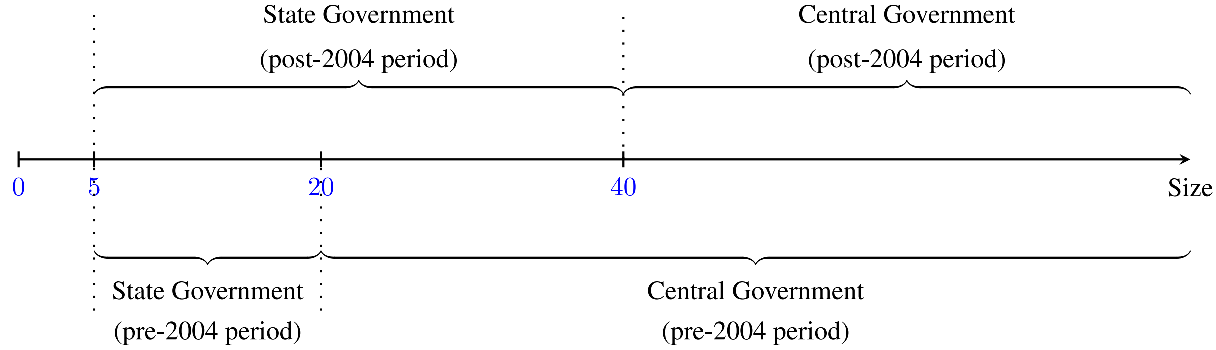
Our paper contributes to several strands of the literature. Researchers and policymakers are becoming increasingly aware of the impact of economic development on environment (Jayachandran 2022, Balboni 2019, Asher et al. 2020), triggering debates in less-developed countries about sustainable ways of developing. We contribute to this important discussion by focusing on the governance framework surrounding environmental policy making shaping this trade-off. Consequently, our work also relates to the effect of decentralization on various governance outcomes such as local public good provision (Kis-Katos and Sjahrir 2017, Gadenne and Singhal 2014, Bardhan 2002), resource utilization (Gadenne 2017), corruption (Fan et al. 2009), and specifically, management and utilization of natural resource, such as forest (Baland et al. 2010, Lund and Treue 2008, René Oyono 2005) and water (Jacoby et al. 2021, Drysdale and Hendricks 2018). Several of these studies examine local management of natural resources at the level of districts or lower, while we focus on devolution of governance responsibility from the national to the regional government. Moreover, researchers typically estimate the effect of decentralization by either exploiting some policy reform that transfers the responsibility of policy implementation completely from a higher to a lower tier (Jacoby et al. 2021), or using over time proliferation of local jurisdictions, i.e., horizontal decentralization (Burgess et al. 2012, Lipscomb and Mobarak 2016), or increase in number of governance tiers, i.e., vertical decentralization (Fan et al. 2009). In our context, degrees of both vertical and horizontal decentralization are kept the same, while the responsibility of a specific policy is *partially* shifted from the higher to the lower tier that creates variation in responsibility *within* a state.

2 BACKGROUND AND INSTITUTIONAL DETAILS

All forest land in India is state property. Hence, if any economic project, such as road or railway construction, canal irrigation, education or medical facilities, mining, etc., requires diversion of forest land, the agency implementing the project needs to get approval from the government. The Forest Conservation Act passed in 1980 set up the institutional framework and rules guiding the approval process. The act and the subsequent rules specify the primary approving authority depending on project size. All applications for approval are made to the relevant ministry of the state government, which verifies the application details and assesses the project quality before forwarding it to the regional office located in various state capitals. For very small projects, with size below 5 hectares, the decisions are made by a high level bureaucrat in the regional office.

For years prior to 2004, projects above 5 hectares and up to 20 hectares were decided by a committee in the regional office consisting of officials and representatives of the state government. For projects above 20 hectares, the state government directly sent the applications to the environment ministry of the central government for approval. In the pre-2004 period, therefore, the state government were the effective approving authority for the projects with size between 5-20 hectares, while projects larger than 20 hectares were decided by the central government. In 2004, an amendment to the act increased the threshold to 40 hectares, increasing the range of the project size for which the state government will be the primary approving authority. The approving authority of the mid-sized projects, i.e., those with sizes between 20 and 40 hectares, therefore, changed from the central to the state government in the post-2004 period. We summarize the rules and their amendment in Figure 1.

Figure 1—Approving Authority as a Function of Project Size

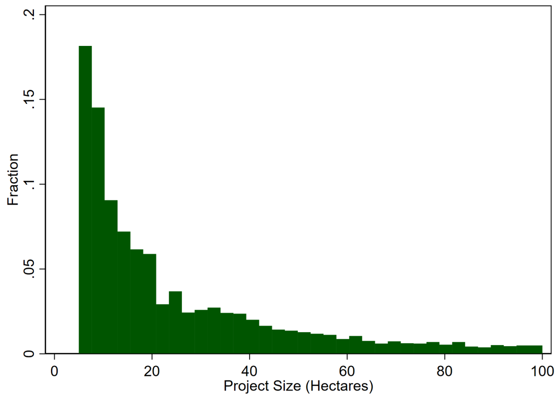


3 DATA

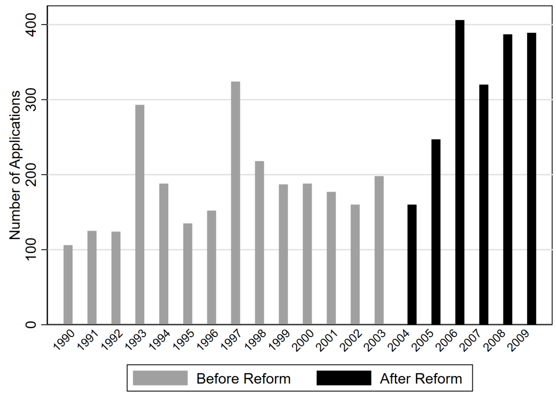
We compile project level data on the universe of projects involving diversion of forest land submitted for government approval in India during the period 1980-2019. The data are available from the website of the Ministry of Environment, Forest and Climate Change (MEFCC), Government of India. The data allow us to extract various details pertaining to each proposal, such as the area of land to be diverted (i.e., project size), its location (state and district), economic purpose of project, date of application and various stages of the approval process and final decision. For our analysis, we focus on projects applied during 1990-2009 with size in the range of 5-100 hectares. We ignore projects prior to 1990 because the rules and practices guiding the implementation of the Forest Conservation Act did not consolidate in the initial years. Moreover, in 2010, the National Green Tribunal was established that allowed citizens to challenge any decision made by the government regarding forest conversion. This can potentially impact the approval decisions. Moreover, the impact could be different across state and central governments. We therefore do not analyze the application data for 2010 onward. As Section 2 describes, projects below 5 hectares are decided by a single bureaucrat and therefore, we ignore the very small projects.

Moreover, for projects above 100 hectares, the application process is different requiring more paperwork and inspections. Hence, we restrict our attention to projects between 5 and 100 hectares.

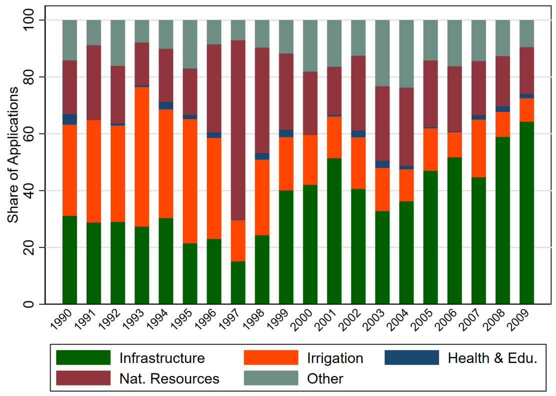
Figure 2—Summary Characteristics of Project Applications



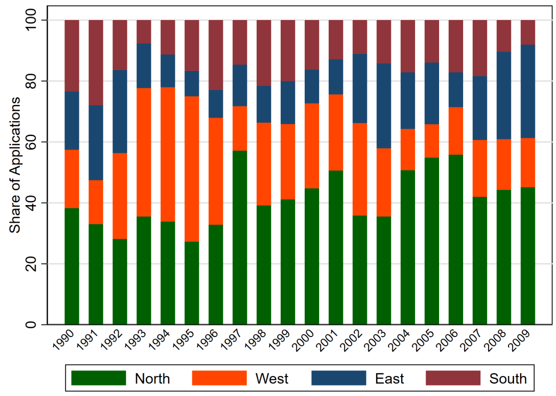
(a) Project Size Distribution



(b) Number of Applications



(c) Types of Projects



(d) Project Across Regions

3.1 Descriptive Statistics

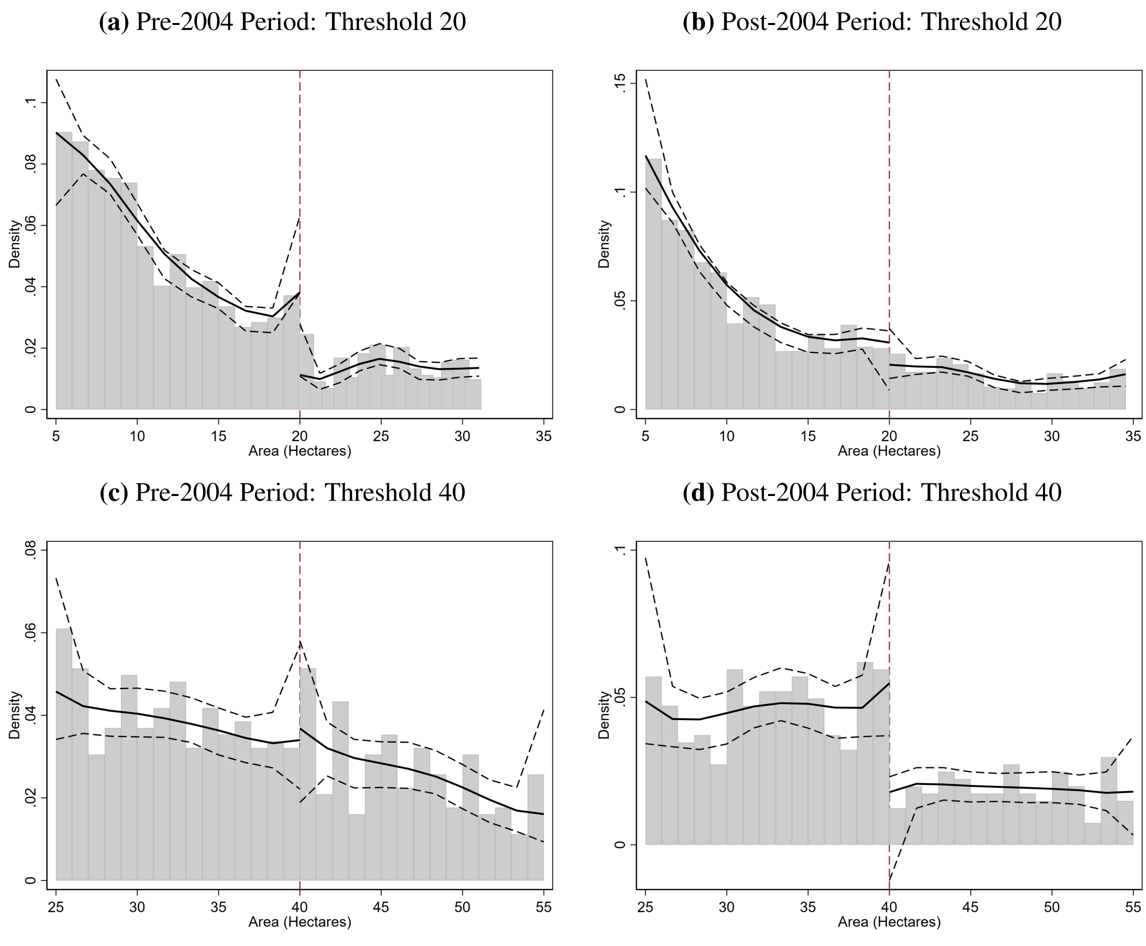
There are 4,548 project applications in our sample. The average project size is 24.36 hectares. Figure 2a shows the distribution of project size conditional on being in the sample. The density of size falls quickly as size increases. Figure 2b shows the yearly number of applications. We observe that the number of applications has increased over the years, especially in the post-2004 period. We categorize the projects into 5 categories - infrastructure, irrigation, natural resources, health and education and others. Infrastructure projects consist of roads, railways, transmission lines, and constitute of 39.47 percent of the sample. Irrigation are the canal projects and are 20.76 percent of applications. Projects involving natural resources are mining and energy generation projects such as hydel, thermal and wind power projects that constitute 25.20 percent of applied projects. Medical and education facilities are 1.34 percent of the sample, and the rest are referred to as others, for which no specific economic purpose was mentioned in the data. Figure 2c shows the evolution of the shares of different types of project applications over the years. While irrigation projects dominated the earlier years in the sample, in the later years the infrastructure projects constitute the plurality of applications. The share of natural resource related projects increased in the middle of the period and then fell down in the last few years.

Figure 2d shows the regional distribution of project applications and its evolution over the years. Around 40 percent of project applications come from Northern states. The share of applications from Western states has come down over the years, while that of Eastern states have increased. The average approval probability of projects is 71.81 percent; it does not exhibit large changes over the sample period.

4 EMPIRICAL FACTS

In this section, we establish certain empirical facts about the approval process under the central and regional governments by exploiting the rule change. This will help us motivate the model and the subsequent analysis.

Figure 3—McCrary Tests Demonstrate Higher Mass of Applications with State Governments



Fact 1: Conditional on project size, regional governments receive more project applications than the central government.

Figure 3 depicts the results of McCrary tests performed around 20 and 40 hectare thresholds in pre- and post-2004 periods. We observe in Figure 3a that there is discontinuous fall in the density at 20 hectares in the pre-2004 period (p-value = 0.04), implying that significantly more applicants with project size of 20 hectares applied to the regional governments relative to the central government. This suggests that conditional on project size, either the approval probability is higher or application cost is lower under regional government. In the post period, projects just above 20 hectares also come under the regional government, eliminating any difference in approval process around that threshold. Consistently, Figure 3b finds that in the post period there is no statistically significant difference in density at 20 hectares (p-value = 0.96). Similarly, Figure 3c shows that in the pre period there was no statistically significant discontinuity in the density at 40 hectares (p-value = 0.38), as projects on both sides of the threshold were processed by the central government. In the post-period, however, regional government processed the projects smaller than 40 hectares. Consistent with our previous result, Figure 3d shows a statistically significant discontinuous fall in the density at 40 hectares in the post-period (p-value = 0.03).

Fact 2: Conditional on size, average approval probability is *lower* under regional government relative to the central government. We refer to projects with size in the interval $[5, 20]$ as small projects, $(20, 40]$ as mid-sized or middle projects and $(40, 100]$ as large projects. The small and large projects were always decided by the regional and central governments, respectively, during the entire sample period. The approving authority of the middle projects, on the other hand, changed from the central government to the regional governments in the post-period. We exploit this fact to estimate the difference in the approval probabilities between the central and regional governments using the following difference-in-difference specification:

$$\begin{aligned} A_{jst} &= \beta_1 Middle_{jst} + \beta_2 Middle_{jst} \times Post_t \\ &+ \beta_3 Large_{jst} + \beta_4 Large_{jst} \times Post_t + \delta_s + \gamma_t + \epsilon_{jst} \end{aligned} \tag{1}$$

where A_{jst} is a dummy that takes value one if the project j located in state s applied in year t is approved and is zero otherwise, $Middle_{jst}$ and $Large_{jst}$ are dummies as defined above, $Post_t$ takes value one for year 2004 onward, and δ_s and γ_t are state and year fixed effects. Our coefficient of interest is β_2 as it estimates the difference between the average approval probabilities under central and regional government, for the mid-sized projects.

Table 1 reports the results. We cluster the standard errors at the level of states, as approval decisions could potentially be correlated across projects from a given state. Column (1) estimates equation 1 without year fixed effects and adding a Post dummy instead, while column (2) estimates the full specification. In both columns, we find that estimate of β_2 is negative and statistically significant at 1%. In column (3) we make the specification more stringent by adding region and project category specific fixed effects. The estimate of β_2 maintains its magnitude, sign and statistical significance. The average approval probability of middle projects is $0.09 - 0.11$ lower under the regional government relative to the central government. This is consistent with the finding that estimate of β_1 is positive, similar in magnitude and statistically significant, suggesting higher approval probability under the central government (in the pre-period). In columns (4)-(6) we drop projects in the size intervals $(15, 25)$ and $(35, 45)$, i.e., projects that are around the threshold values. This is to allay any concerns about endogenous sorting of projects (by altering the size) into one side of the threshold. The result however remains robust. The estimate of β_2 remains stable, negative and statistically significant.

Fact 2, in conjunction with the first fact, suggests that the regional governments receive, on average, worse *quality* of applications of a given size, compared to the central government. Quality of a project denotes the net economic value it will generate for the local area, conditional on its size. The quality of a project is assessed by local level officials who make inspections of the project site and submit their assessment to the approving authority. The approving authority, therefore, is likely to be aware of project quality, and hence, can condition the approval decision on it. Therefore, even if regional governments have a higher approval probability or lower application cost for a project with a given size and quality (which can justify Fact 1), its *average* approval probability conditional on size can be lower, due to the adverse selection effect.

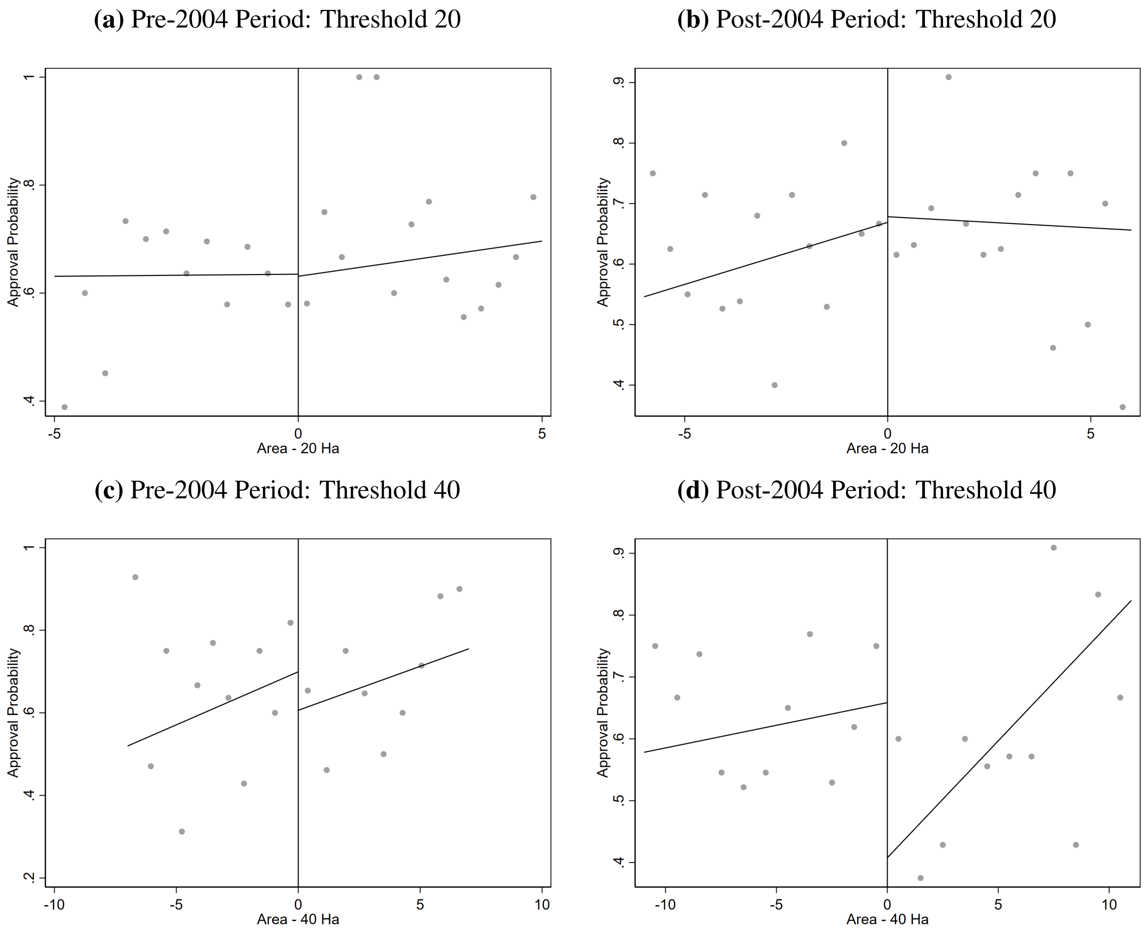
Table 1—Approval Rates and Govt.

	1(Project Approved)					
	(1)	(2)	(3)	(4)	(5)	(6)
Post	0.061***			0.064***		
	(0.018)			(0.021)		
Middle	0.126***	0.120***	0.126***	0.148***	0.140***	0.134***
	(0.022)	(0.023)	(0.025)	(0.030)	(0.030)	(0.032)
Large	0.135***	0.128***	0.139***	0.168***	0.156***	0.152***
	(0.022)	(0.023)	(0.025)	(0.026)	(0.026)	(0.029)
Middle × Post	-0.099***	-0.090***	-0.113***	-0.119**	-0.108**	-0.134***
	(0.032)	(0.033)	(0.035)	(0.046)	(0.047)	(0.050)
Large × Post	-0.033	-0.031	-0.053	-0.036	-0.032	-0.044
	(0.034)	(0.034)	(0.038)	(0.038)	(0.038)	(0.042)
Mean|Small,Pre	0.65	0.65	0.65	0.63	0.63	0.63
R2	0.07	0.08	0.15	0.09	0.10	0.18
N	4484	4484	4144	3062	3062	3062
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Category FE	Yes	Yes	No	Yes	Yes	No
Year FE	No	Yes	No	No	Yes	No
Region x Year FE	No	No	Yes	No	No	Yes
Cat. x Year FE	No	No	Yes	No	No	Yes
Sample	Whole	Whole	Whole	Restricted	Restricted	Restricted

Notes: Data is at the level of project-year. All projects with area 5-100 hectares are in the sample. The time period is 1990-2009. The dependent variable is a dummy that takes value one if the project was approved and is zero otherwise. Middle is a dummy that takes value one if the project area is between 20-40 hectares, and large if it is between 40-100 hectares. Columns (1)-(3) consider the full sample while the last three columns drop projects with area in the range 15-25 hectares and 35-45 hectares. Post is an indicator for years 2004 and after. All regressions include state and project category fixed effects. Columns (2) and (5) include year fixed effects and columns (3) and (6) have region and project category specific year fixed effects. Standard errors clustered at the state level are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Fact 3: At the size threshold that demarcates approving authorities, approval probability is not discontinuous in the pre-period and falls discontinuously in the post-period. We use the regression discontinuity design (RDD) and test for discontinuity in the approval rate as a function of project area around the threshold values of 20 and 40 hectares. Figure 4a shows that there is no discontinuous change in the approval probability at 20 hectares in the pre-period. Appendix Table A1 Panel A reports the RD estimates under varying specifications and find no statistically significant discontinuity. Therefore, even though state governments received more applications at 20 hectares (Fact 1), their approval rates were the same on average. This is true in the post-period as well (Figure 4b and Appendix Table A1 Panel B). For the post-period the threshold shifted to 40 hectares. Figure 4d shows that there is a large discontinuous fall in the approval probability at that threshold in the post-period. Appendix Table A2 Panel B report the estimates. The RDD coefficient without any covariate is -0.25 which is large, and is statistically significant at 1%. The estimated discontinuity increases to 0.43 with additional controls in terms of staate, year and project category fixed effects. Moreover, no such discontinuity existed in the pre-peiord (Figure 4c and Appendix Table A2 Panel A). Hence, even though the approval rate is on average lower for state governments (Fact 2), around the threshold value it is lower for the central government.

Figure 4—Regression Discontinuity of Approval Probability at Size Thresholds



(a) Pre-2004 Period: Threshold 20

(b) Post-2004 Period: Threshold 20

(c) Pre-2004 Period: Threshold 40

(d) Post-2004 Period: Threshold 40

Fact 3 may appear to be inconsistent with Fact 2. However, notice that while average approval probability for project sizes away from the threshold may be subject to selection effect, for projects in the neighborhood of threshold sizes, there might be an additional sorting effect in action. If applying to the state government is more beneficial for a project, as Fact 1 suggests, applicants with project size just above the threshold may prefer to reduce the project size and apply with the state government. Hence, some projects may endogenously sort themselves into the left side of the threshold. Hence, the greater mass of applications observed in Fact 1 can be due to both selection and sorting. If sorting is costly for the applicant, then only higher quality projects will engage in it, leaving lower quality of applications just to the right side of threshold. This will bring down the average approval probability just to the right side of the threshold, and increase it on the left. This may explain Fact 3.

All the three facts presented above suggest that either state governments evaluate forest conversion applications differently than the central government or application costs are differential across the two types of government or both. However, in order to empirically estimate the relative application cost and the relative preference weight that state governments put on economic development vis-a-vis environmental concerns, compared to the central government, we need to model the interaction between the applicants and the government. Moreover, while sorting is an artefact of the threshold rule, selection is a more general concern with decentralization. In the following section, we build a model that abstracts away from the sorting issue and examines the application and approval decisions of forest conversion projects by taking into account the selection problem. We bring in the sorting concern later to estimate the relative importance of sorting vis-a-vis selection in explaining the density discontinuity examined under Fact 1.

5 MODEL

Consider the decision of an applicant who has a project that requires conversion of forest land of size S and has project quality $z \sim F_z(z)$. A project is therefore denoted by the pair (z, S). z is observable to the applicant and the approving authority, but is unobservable to the researcher. S is observable to everyone. Project (z, S) generates a value $v(z, S) = zq(S)$ where $q(\cdot)$ is strictly increasing and strictly concave in S. The applicant has to decide whether to apply for the project or not. A government, upon receiving an application of a project, decides whether to approve it or not. We assume that the assignment of projects to a government is exogenous and examine the consequences of being assigned to the central or state government. Hence, we do not allow any possibility of an applicant changing the project size to endogenously choose the approving government. Such sorting concerns may be valid for projects near the threshold size. We abstract away from it in our baseline model which we calibrate using project data away from the threshold, where sorting concern is absent. In Section 7.1, we augment our model to bring in sorting possibilities and estimate the new model on the data in the neighborhood of the thresholds.

5.1 Decision of Government

We consider the payoff of a government (either Centre or State) i.e., $g \in \{C, S\}$, from approving a project $\{z, S\}$:

$$U_g(z, S) \;=\; b_g z v(S) - \eta c_G(S)$$

where b_g is how much government g weights the economic value generated by a project. $-c_G(S)$ is the conservation value of forest land of size S. Stated otherwise, $c_G(S)$ is the conservation cost of approving the project. We assume that both governments have the same cost function, which is strictly increasing and weakly convex in S. $\eta_g \sim F_\eta(\eta)$ is project-specific idiosyncratic taste (or, preference) shock that a government receives while processing the application. This creates uncertainty about the outcome of the application at the time of seeking approval. b_g captures the relative importance of economic value of a project vis-a-vis forest conservation in government g's payoff. The government will approve the project as long as $U_g \geq 0$, which implies that the ex-ante approval probability of a project is:

$$P_g(z, S) \;=\; F_\eta\Big[b_g z \phi(S)\Big] \tag{2}$$

where $\phi(x) = \frac{q(x)}{c_G(x)}$ is the benefit-cost ratio for the government.

Lemma 1 *Conditional on size, higher quality projects are more likely to be approved, i.e., $\partial P/\partial z > 0$. Moreover, conditional on the quality of the project, larger projects are less likely to be approved, i.e., $\partial P/\partial S < 0$.*

See Appendix B.1 for the proof.

5.2 Decision of the Applicant

The applicant's expected payoff from applying to a government g, denoted by $V(z, S)$, is therefore given by:

$$V_g(z,S) = \underbrace{P_g(z,S)v(z,S)}_{\text{Expected Benefit from the project}} - \lambda_g c_A(S) \tag{3}$$

where $c_A(S)$ is the application cost incurred by the applicant. $c_A(S)$ is strictly increasing and weakly convex function. λ_g is a cost-shifter of applying to a particular type of government, which is a reduced-form way of capturing differential costs that an applicant might have of applying to either the state or central governments.

Given the above structure, an applicant will apply for the project with a government g as long as $V_g(z, S) \geq 0$. Since $\partial V_g(z, S)/\partial z > 0$, it implies that for a given S, there is a threshold $z^*_g(S)$ such that the applicant will apply only if $z \geq z^*_g(S)$, where $z^*(S)$ is determined by:

$$P_g\left[z^*_g, S\right] \times z^*_g \psi(S) = \lambda_g \tag{4}$$

where: $\psi(S) = \frac{q(S)}{c_A(S)}$ and similar to $\phi(S)$, $\psi'(S) < 0$.

Lemma 2 *The threshold quality (z^*) is increasing in the size of the project i.e., $\partial z^*_g/\partial S > 0$.*

See Appendix B.2 for the proof. Intuitively, since larger projects (higher S) have a lower probability of being approved and lower benefits (net of costs), they have to be even more productive (higher z) to be proposed. The mass of *applied* projects of size S, denoted by the PDF $\xi_g(S)$, will be the set of projects for $z > z^*_g$ so that:

$$\xi_g(S) = 1 - F_z(z^*_g(S)) \tag{5}$$

As is evident from the equation, the height of the PDF declines with S since $\partial z^*_g/\partial S > 0$. Lastly, the average approval probability for all applied projects of a given size S is therefore given by:[4]

$$\overline{P}_g(S) = \int_{z \geq z^*_g(S)} P_g(z,S) \frac{dF_z(z)}{1 - F_z(z^*_g(S))} \tag{6}$$

6 MODEL CALIBRATION

6.1 Parameterization

To take the model to the data, we make the following assumptions: (i) we assume that the distribution of project quality follows a Pareto distribution with a shape parameter θ i.e., $z \sim Pareto(\theta)$ i.e., $F_z(z) =$

[4]In Section C, we provide descriptive evidence to validate our assumptions and empirical patterns generated by the model.

$1 - z^{-\theta}$; (ii) we assume that η follows a Uniform distribution on $[0, 1]$ i.e., $F_\eta(\eta) = \eta$.[5] With these distributional assumptions, we can now simplify the above theoretical equations to obtain:

$$P_g(z, S) = b_g z \phi(S) \qquad \text{(From Equation 2)} \tag{7}$$

$$z_g^*(S) = \sqrt{\frac{\lambda_g}{b_g \phi(S)\psi(S)}} \qquad \text{(From Equation 4)} \tag{8}$$

$$\xi_g(S) = (z_g^*)^{-\theta} \qquad \text{(From Equation 5)} \tag{9}$$

$$\overline{P}_g(S) = E(P_g(z)|S) = \frac{\theta}{\theta - 1} \times \underbrace{b_g z_g^* \phi(S)}_{=P_g(z_g^*, S)} \qquad \text{(From Equation 6)} \tag{10}$$

$$V(P_g(S)) = Var(P_g(z)|S) = \frac{2}{\theta - 2}\overline{P}_g^2 \tag{11}$$

6.2 Identification

We normalize $b_c = \lambda_c = 1$ so that $b_r = b$ and $\lambda_r = \lambda$ can now only be interpreted relative to those of the Central government. Given this normalization, note from the above equations that:

$$\lambda = \frac{\overline{P}_r z_r^*}{\overline{P}_c z_c^*} \quad \text{and } b = \frac{\overline{P}_r / z_r^*}{\overline{P}_c / z_c^*}$$

This implies that in the ideal case, if we were able to *separately* observe the distribution of applications for *both* the Centre and State, we can back these out easily. Our policy change, described previously, provides us with a unique way to observe this: since approval for projects in the interval $S \in \{20, 40\}$ were de-centralized from the Centre to the State, we can use this policy reform, along with the distribution and outcome of applications to identify λ and b above. However, we cannot simply take these ratios from the data since the "treatment" also confounds a time-trend in the applications and approval probabilities over time.

To see this, consider two time periods $t = \{0, 1\}$ corresponding with before and after the policy reform. Furthermore, assuming that b and λ do not change over time, the only source of variation through which $\overline{P}_g$ and $z^*(S)_g$ can change over time are through the $\psi(S)$ and $\phi(S)$, which is realistic since the production and cost functions might change over time.

For a government g, we therefore assume that: $\phi_{g1}(S) = \alpha_g \phi_0(S)$ and $\psi_{g1}(S) = \beta_g \psi_0(S)$.[6] We now take advantage of the policy reform, which was only applicable to $S \in (20, 40)$. To eliminate endogenous sorting across the thresholds, we consider the interval $S \in (25, 35)$. Note from the above that conditional on size:

$$\underbrace{\left[\frac{z_1^*}{z_0^*}\right]^{\text{MID}}}_{\text{Data}} = \frac{z_{r1}^*}{z_{c0}^*} = \sqrt{\frac{\lambda}{b}} \times \sqrt{\frac{\phi_{c0}\psi_{c0}}{\phi_{r1}\psi_{r1}}} = \underbrace{\sqrt{\frac{\lambda}{b}}}_{\text{= Policy Impact}} \times \underbrace{\sqrt{\frac{1}{\alpha_r \beta_r}}}_{\text{= Time Trend}} \tag{12}$$

[5] Restriction to the range $[0, 1]$ is without loss of generality. If η is distributed uniformly over $[0, K]$, we can rewrite $\eta c_G(S)$ as $\eta' c_G'(S)$ where $c_G'(S) = K c_G(S)$ and $\eta' = \eta/K$ is uniform over $[0, 1]$.

[6] Note that in theory, *both* the initial level of $\{\psi(S), \phi(S)\}$ as well as their change over time $\{\alpha, \beta\}$ can vary across Centre and State governments. However, we do not have any empirical variation to identify these separately because the institutional context perfectly separates the approval decisions by the two governments across the size distribution. Therefore we have to assume assume that they are the same in the pre-policy reform period.

$$\underbrace{\left[\frac{\overline{P}_1}{\overline{P}_0}\right]^{\text{MID}}}_{\text{Data}} = \frac{\overline{P}_{r1}}{\overline{P}_{c0}} = b \times \frac{z^*_{r1}}{z^*_{c0}} \times \frac{\phi_{r1}}{\phi_{c0}} = \underbrace{\sqrt{b\lambda}}_{=\text{ Policy Impact}} \times \underbrace{\sqrt{\frac{\alpha_r}{\beta_r}}}_{=\text{ Time Trend}} \tag{13}$$

Time Trend: From the above equation, $\{\alpha_r, \beta_r\}$ denote the changes in the $\{\phi, \psi\}$ functions for the state government between the two time periods. We take advantage of the fact that the approval decisions for applications under 20 Ha. were always under the regional governments in both the pre- and post-period to calculate these. Specifically, we consider the probability of approval and empirical distribution of applications for $S \in (5, 15)$ Ha. (to mitigate concerns from sorting between 15-20 Ha. projects) and note that:

$$\underbrace{\left[\frac{z^*_1}{z^*_0}\right]^{\text{SMALL}}}_{\text{Data}} = \frac{z^*_{c1}}{z^*_{c0}} = \sqrt{\frac{\phi_{c0}\psi_{c0}}{\phi_{c1}\psi_{c1}}} = \sqrt{\frac{1}{\alpha_r\beta_r}} \tag{14}$$

$$\underbrace{\left[\frac{\overline{P}_1}{\overline{P}_0}\right]^{\text{SMALL}}}_{\text{Data}} = \frac{\overline{P}_{c1}}{\overline{P}_{c0}} = \frac{z^*_{c1}}{z^*_{c0}} \times \frac{\phi_{c1}}{\phi_{c0}} = \sqrt{\frac{\alpha_r}{\beta_r}} \tag{15}$$

Denote $\mathcal{Z}^X = \left[\frac{z^*_1}{z^*_0}\right]^{\text{X}}$ and $\mathcal{P}^X = \left[\frac{\overline{P}_1}{\overline{P}_0}\right]^{\text{X}}$. Substituting Equations (14) and (15) in (12) and (13), we get:

$$\mathcal{Z}^{\text{MID}} = \sqrt{\frac{\lambda}{b}} \times \mathcal{Z}^{\text{SMALL}} \quad \text{and} \quad \mathcal{P}^{\text{MID}} = \sqrt{b\lambda} \times \mathcal{P}^{\text{SMALL}}$$

$$\Rightarrow b = \frac{\mathcal{P}^{\text{MID}} / \mathcal{P}^{\text{SMALL}}}{\mathcal{Z}^{\text{MID}} / \mathcal{Z}^{\text{SMALL}}} \quad \text{and} \quad \lambda = \frac{\mathcal{P}^{\text{MID}}}{\mathcal{P}^{\text{SMALL}}} \times \frac{\mathcal{Z}^{\text{MID}}}{\mathcal{Z}^{\text{SMALL}}} \tag{16}$$

6.3 Parameter Calibration

Table 2—Values of (θ, b, λ) Based on Different Sample Restrictions

	θ	b	λ	$\sqrt{\lambda/b}$	$\sqrt{b\lambda}$	Sorting Channel
Whole Sample, Both	5.33	0.9434	0.8880	0.9702	0.9153	0.1285
Whole Sample, Pre-Period	5.59	0.9420	0.8893	0.9716	0.9153	0.1286
Whole Sample, Post-Period	5.31	0.9435	0.8879	0.9701	0.9153	0.1285
Restricted, Both	5.33	0.9434	0.8880	0.9702	0.9153	0.1285
Restricted, Pre-Period	5.44	0.9428	0.8886	0.9708	0.9153	0.1286
Restricted, Post-Period	5.31	0.9435	0.8879	0.9701	0.9153	0.1285
Restricted, Both	5.33	0.9434	0.8880	0.9702	0.9153	0.1285

Notes: Restricted sample excludes those applications between 15-45 Ha.

Given the above discussion and identification, we now turn to estimating the three parameters of interest, namely: $\{\theta, b, \lambda\}$. Our empirical calibration will closely follow generating the empirical counterparts to Equations (8)-(11). We proceed as follows: first, we pool all projects in the pre- and post-reform period and for each size S, calculate the empirical density and the average and variance of the approval probability. To gain precision (since S is a continuous distribution) we discretize S in levels of 1 Ha.[7]

STEP 1. Re-arranging Equation (11), $\hat{\theta} = 2(1 + \overline{P}_g^2/V(P_g))$. Note that since the RHS of the above equation is observable in the data for each project size S, the above exercise gives us a $\hat{\theta}$ for each S. Given the nature of the policy, our preferred value of θ is the median value of $\hat{\theta}(= 5.33)$ across $S \notin (15, 45)$. However, in Table 2, we report the values across various other sub-samples in the data, which range from 5.31-5.59.

STEP 2. Given $\hat{\theta}$ and the empirical density at size S i.e., $\xi(S)$, we can invert Equation (9) to obtain the productivity of the marginal project i.e., $z_g^*(S) = (\xi_g(S))^{-1/\hat{\theta}}$.

STEP 3. Given $z_g^*(S)$ as well as $\overline{P}_g(S)$, in both the pre- and post-periods, we average over the size distribution in $X = \{\text{SMALL,MID}\}$ and then calculate the ratios $\mathcal{Z}^{\text{X}}$ and $\mathcal{P}^{\text{X}}$ defined previously. Substituting them in Equation (16), we get $b = 0.94$ and $\lambda = 0.89$. As reported in Columns (4)-(7) of Table 2, these values are robust to alternative values of θ.

Validation Exercise: We compare the calibrated parameter values with the coefficient estimates from Table 1. The model gives us,

$$\frac{\bar{P_{r0}}^{MID} - \bar{P_{c0}}^{MID}}{\bar{P_{c0}}^{MID}} = (\sqrt{b\lambda} - 1)$$

Numerator of LHS is the coefficient β_2 estimated in Table 1. Denominator is directly observed in data. Hence,

$$\sqrt{b\lambda} = \frac{-0.09}{0.77} + 1 = 0.88$$

which compares well with Column (5) of Table 2.

7 IMPACT OF DECENTRALIZATION

The above exercise now provides us with the necessary information to understand the impact of decentralization. In particular, there are three channels through which this impact can be measured, the first two being more general, and the last one being an artifact of the threshold nature of the decentralization policy. The first channel is the increase in the probability of approval *conditional* on application, which from Equation 7, is simply b. This implies (from the calibration above) that conditional on applying, the probability of approval decreased by 9%.

A second channel speaks to the lower cost of application, λ, that along with b, drives the selection of projects that now make applications. Table 2 shows that λ is 0.89, i.e., cost of application is 11% lower under state government. The consequent selection effect can be measured by the increase in the mass of mid-sized projects that now apply to the state. This is given by $(\sqrt{\lambda/b})^{-\theta} = 1.18$, which implies that 18% more projects that would not have been applied under the Central government regime, now apply under the state governments. The selection effect, therefore, attenuates the direct positive effect of decentralization on conservation. Additionally, since higher mass of applications comes about by lowering the threshold quality z^*, decentralization also reduces the average quality of approved projects

[7] The results are robust but noisier to discretizing the project size in 1.5 Ha. or 2 Ha. bins instead.

by 3%. Put together (as implied in Equation 13), the average probability of approvals (measured by $\sqrt{b\lambda}$) is now 0.92 or 8% lower after the policy reform. Coupled with a 18% increase in application volume, it implies a net 8.6% ($= (0.92 \times 1.18) - 1$) *increase* in deforestation due to decentralization.

The first two channels measure a general decomposition of the impact of decentralization on the probability of approvals. However, since the decentralization policy is implemented at specific thresholds (20 and 40 Ha.), there is also a sorting of projects close to the thresholds (as indicated in Fact 1 and Figure 3 previously). To examine the impact of sorting, we augment our model with the possibility of applicants applying to a different level of government by changing the project size, when the optimal size is close to the threshold. This allows us to decompose the higher empirical density observed to the left of threshold (Figure 3) into selection and sorting.

7.1 A Model of Sorting

Now consider an extension of the model where applicants with projects near the threshold size can manipulate their size in the application and sort across the threshold. Consider therefore a project with true quality and size $\{z, S\}$. Based on the "ideal" size, let g be the government that the application would have to be approved by. However, the applicant now faces an incentive to manipulate the size of her application and report a size S', also in the neighborhood of the threshold, so as to be approved by a government g'. The key gain from manipulation is either a higher weight that g' puts on the project and/or lower costs of applying to g'. Note for completeness of the argument, that manipulation will also change the valuation of the project and its application cost, thereby, changing $\phi(S)$ and $\psi(S)$ to $\phi(S')$ and $\psi(S')$. However, for exposition purposes, we assume that they these functions are sufficiently concave near the threshold such that effect of marginal changes in S on approval probabilities and application costs can be ignored. The first order effect of manipulation will come from difference in b_g and λ_g across governments. We therefore analyze sorting by fixing S and letting the applicant choose which government to apply under. Sorting, however, is costly, since it involves planning the implementation of the project with a (marginally) different size. The sorting or manipulation cost is denoted by an increasing and convex function $c_M(S)$.

We define $\tau(S) = c_M(S)/c_A(S)$ and make two assumptions: first, we assume that $\tau'(S) > 0$ i.e., it is costlier to manipulate larger projects as compared to smaller ones. Second, we assume that $\tau(S) > |b - \lambda|$ i.e., the costs are "sufficiently large" such that not everyone would want to manipulate. The second assumption draws from the empirical fact that we observe non-zero density in the number of applications on either side of the threshold. Lastly, from the previous discussion, we would like to remind the reader that:

$$z_c^* = \frac{1}{\sqrt{\phi(S)\psi(S)}} \qquad \text{and} \qquad z_r^* = \sqrt{\frac{\lambda}{b}} \times \frac{1}{\sqrt{\phi(S)\psi(S)}}$$

Lemma 3 *An applicant would never want to manipulate to move from a regional government to the Central government as long as $\tau(S) > b - \lambda$.*

See Appendix B.4 for the proof.

Lemma 4 *All projects with a quality $z \geq z_M^*(S)$ will manipulate their projects from the Central to Regional government, where*

$$z_M^* \equiv M z_c^* = \sqrt{\frac{\lambda + \tau(S) - 1}{b - 1}} \times z_c^*. \tag{17}$$

Moreover, the incentive to manipulate decreases with the size of the project.

See Appendix B.5 for the proof.

Sorting at 40 Ha.: We now decompose the discontinuous density observed in Fact 1 into selection and sorting. We do this separately for 40 Ha. and 20 Ha. The ratio of the density of projects in post- and pre-period to the left of the 40 Ha. threshold can be given by:

$$\begin{aligned}
\frac{\xi_{1r}}{\xi_{0c}} &= \frac{(1 - F(z_M^*)) + (1 - F(z_{1r}^*))}{1 - F(z_{0c}^*)} \\
&= M(40)^{-\theta} \left(\frac{z_{1c}^*}{z_{0c}^*}\right)^{-\theta} + \left(\frac{z_{1r}^*}{z_{0c}^*}\right)^{-\theta} && \text{(From Equation 9)} \\
&= \underbrace{\left[M(40)\sqrt{\frac{1}{\alpha_c \beta_c}}\right]^{-\theta}}_{\text{Sorting}} + \underbrace{\left[\sqrt{\frac{\lambda}{b}}\sqrt{\frac{1}{\alpha_r \beta_r}}\right]^{-\theta}}_{\text{Selection}} && \text{(From Equation 12)}
\end{aligned}$$

Empirical Estimation of Sorting: We use the empirical distributions of the density in the range [35,40] in pre and post periods to calculate their ratio which enables us to estimate the sorting effect $M(40)^{-\theta}$ since the selection effect ($\sqrt{\lambda/b}^{-\theta}$) and the time trends are already estimated. We find that about 12% of the difference in density at 40 Ha. in the post period can be explained by sorting.

Sorting at 20 Ha.: Consider the mass of projects to the *left* of the 20 Ha. threshold. Then the ratio of the density of projects in post- and pre-period is be given by:

$$\begin{aligned}
\frac{\xi_{0r}}{\xi_{1r}} &= \frac{(1 - F(z_M^*)) + (1 - F(z_{0r}^*))}{1 - F(z_{1r}^*)} \\
&= \frac{(z_M^*)^{-\theta} + (z_{0r}^*)^{-\theta}}{(z_{1r}^*)^{-\theta}} \\
&= \frac{(M(20) z_{0c}^*)^{-\theta} + (z_{0r}^*)^{-\theta}}{(z_{1r}^*)^{-\theta}} \\
&= \left[M(20)^{-\theta} \left(\frac{z_{0c}^*}{z_{1r}^*}\right)^{-\theta} + \left(\frac{z_{0r}^*}{z_{1r}^*}\right)^{-\theta}\right] \\
&= \left[M(20)^{-\theta} \left(\frac{z_{1r}^*}{z_{0r}^*} \times \frac{z_{0r}^*}{z_{0c}^*}\right)^{\theta} + \left(\frac{z_{1r}^*}{z_{0r}^*}\right)^{\theta}\right] \\
&= \left[\underbrace{M(20)^{-\theta}}_{Sorting} + \underbrace{\left(\sqrt{\frac{\lambda}{b}}\right)^{-\theta}}_{Selection}\right] \times \frac{1}{\left(\sqrt{\frac{\lambda}{b}}\sqrt{\frac{1}{\alpha_r \beta_r}}\right)^{-\theta}}
\end{aligned}$$

The equation above shows that the density ratios at 20 Ha. threshold can not completely decomposed into sorting and selection, as the RHS of the equation above shows that the selection effect appears multiplicatively with the sorting effect. Hence, we are unable to empirically estimate the relative importance of sorting at the 20 Ha. threshold.

8 CONCLUSION

We examine the consequence of decentralized environmental policy-making in India on conservation and economic development. We compile project level data on the universe of proposals requiring diversion of forest land for economic purposes that were submitted to the Indian government for approval during the period 1990-2009. Our identification comes from a rule change in 2004 that increased the upper limit on the size of a project that state governments could approve. The projects with sizes that fall between the previous and post-reform limits, therefore, experienced a switch in their approving authority from the central to the state government. We show that approval probability reduced by 9 percentage points because of decentralization, implying that state governments care more about conservation than the center. However, we also find that the density of applications is significantly higher under the state government relative to the center, suggesting that applicants prefer to apply to the state government. We propose a model that endogenizes both applications and approvals to structurally recover the state government's relative preference weight on development work and relative application cost under state. We find that state governments put 9% lower weight on economic projects and also have 11% lower application cost. The lower application cost results in 6% increase in the mass of applications, attenuating the positive impact on conservation by half. Our analysis, therefore, unpacks the overall effect of decentralization into direct effect, due to differential preferences and application costs under the two governments, and the indirect effect, through the channel of selection that such preference and cost differences induce. Moreover, we find that the average quality of approved projects also falls due to the selection effect. Hence, decentralization increases forest conservation, albeit in a muted manner, while reducing the quality of sanctioned development work.

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APPENDIX

A Tables and Figures

Table A1—Approval Rates at the 20 Ha. Threshold

	1(Project Approved)			
	(1)	(2)	(3)	(4)
Panel A: Before 2004 Policy Reform				
RD_Estimate	-0.011	0.025	0.051	0.053
	(0.081)	(0.075)	(0.079)	(0.080)
Con. p-value	0.892	0.742	0.521	0.508
Robust p-value	0.862	0.771	0.621	0.585
Bandwidth	5.23	4.89	4.74	3.49
N	2575	2575	2575	2575
Panel B: After 2004 Policy Reform				
RD_Estimate	0.024	-0.023	-0.003	-0.051
	(0.165)	(0.135)	(0.127)	(0.072)
Con. p-value	0.886	0.866	0.980	0.475
Robust p-value	0.791	0.707	0.866	0.408
Bandwidth	6.34	5.96	6.04	4.61
N	1909	1909	1909	1909
BW Type	CCT	CCT	CCT	CCT
State FE	No	Yes	Yes	Yes
Year FE	No	No	Yes	Yes
Category FE	No	No	No	Yes

Notes: Data is at the level of project-year. The table reports regression discontinuity estimates on approval probability of projects around the size threshold of 20 Ha. Panel A restricts the sample of pre-2004 period, while Panel B considers the post-2004 period sample. Column (1) does not add any covariate in the RDD estimation, while columns (2)-(4) cumulatively add state, year and project category fixed effects. Standard errors clustered at the state level are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A2—Approval Rates at the 40 Ha. Threshold

	1(Project Approved)			
	(1)	(2)	(3)	(4)
Panel A: Before 2004 Policy Reform				
RD_Estimate	-0.087	-0.072	-0.066	-0.037
	(0.064)	(0.058)	(0.063)	(0.075)
Con. p-value	0.175	0.209	0.294	0.628
Robust p-value	0.084	0.119	0.163	0.481
Bandwidth	7.35	7.83	8.49	8.21
N	2575	2575	2575	2575
Panel B: After 2004 Policy Reform				
RD_Estimate	-0.247***	-0.359***	-0.479***	-0.429***
	(0.088)	(0.107)	(0.138)	(0.148)
Con. p-value	0.005	0.001	0.001	0.004
Robust p-value	0.015	0.002	0.000	0.002
Bandwidth	11.11	8.33	6.98	7.25
N	1909	1909	1909	1909
BW Type	CCT	CCT	CCT	CCT
State FE	No	Yes	Yes	Yes
Year FE	No	No	Yes	Yes
Category FE	No	No	No	Yes

Notes: Data is at the level of project-year. The table reports regression discontinuity estimates on approval probability of projects around the size threshold of 40 Ha. Panel A restricts the sample of pre-2004 period, while Panel B considers the post-2004 period sample. Column (1) does not add any covariate in the RDD estimation, while columns (2)-(4) cumulatively add state, year and project category fixed effects. Standard errors clustered at the state level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

B Mathematical Proofs

B.1 Approval Decision of the Government

Lemma 1 states that *"conditional on size, higher quality projects are more likely to be approved i.e., $\partial P/\partial z > 0$. Moreover, conditional on the quality of the project, larger projects are less likely to be approved i.e., $\partial P/\partial S < 0$."* ***Proof***: Given that $F'_\eta(x) > 0$, it is obvious to see that $\partial P_g/\partial z > 0$. Let e_ϕ be the elasticity of ϕ w.r.t. S and let e_q and e_c be defined similarly for the functions q and c. Then, $e_\phi = e_q - e_c$. Additionally,

$$e_q = \frac{q^{'}(S)S}{q(S)} < 1 \quad \text{since } q(S) \text{ is strictly concave, and}$$

$$e_c = \frac{c^{'}(S)S}{c(S)} \geq 1 \quad \text{since } c(S) \text{ is weakly convex}$$

which implies $e_\phi < 0$. Lastly,

$$\frac{\partial P}{\partial S} = \underbrace{\frac{\partial F_\eta}{\partial \phi}}_{>0} \times \underbrace{\frac{\partial \phi}{\partial S}}_{<0} < 0$$

■

B.2 Threshold Project Quality and Project Size

Lemma 2 states that *"the threshold quality is increasing int he size of the project i.e., $\partial z_g^*/\partial S > 0$."* ***Proof***: Rearranging Equations (2) and (4) we have:

$$\ln F_\eta(z_g^* \phi(S)) + \ln z_g^* + \ln \psi(S) = \ln \lambda_g$$

$$\frac{b_g F'_\eta(x)}{F_\eta(x)} \left[\phi(S)\frac{\partial z_g^*}{\partial S} + z_g^* \phi'(S)\right] + \frac{1}{z_g^*}\frac{\partial z_g^*}{\partial S} + \frac{\phi'(S)}{\phi(S)} = 0 \text{ (Differentiating both sides)}$$

$$\underbrace{\left[\frac{F'_\eta(x)}{F_\eta(x)} b_g \phi(S) + \frac{1}{z_g^*}\right]}_{>0} \frac{\partial z_g^*}{\partial S} = -\left\{\underbrace{\frac{1}{\phi(S)}}_{>0} + \underbrace{\frac{F'_\eta(x)}{F_\eta(x)}}_{>0} b_g z_g^*\right\} \underbrace{\phi'(S)}_{<0} > 0$$

■

B.3 Parameterization of the Model

We now provide details on parameterization of the model. As discussed in the paper, we assume $z \sim Pareto(\theta)$ i.e., $F(z) = 1 - z^{-\theta}$, and that $\eta \sim U(0, K)$. Based on these assumptions, we can derive Equations (7)-(9) from their corresponding theoretical counterparts. Turning to Equations (10), we use a property of the Pareto distribution where if $x \sim Pareto(\theta)$, then for any $a < \theta$, $E(x^a|x \geq x^*) =$

$\frac{\theta}{\theta-a}(x^*)^a$. This implies that the average approval probability is given by:

$$\begin{aligned}
\overline{P}_g(S) &= \int_{z\geq z_g^*(S)} P_g(z,S)\frac{dF_z(z)}{1-F_z(z_g^*(S))} \\
&= b_g\phi(S)\int_{z\geq z_g^*(S)} \frac{zdF_z(z)}{1-F_z(z_g^*(S))} \\
&= b_g\phi(S)E(z|z\geq z_g^*) \\
&= \frac{\theta}{\theta-1}b_g\phi(S)\times z_g^* = \frac{\theta}{\theta-1}P_g(z_g^*)
\end{aligned}$$

In a similar way, we can calculate the variance of approval probability (Equation 11) as follows:

$$\begin{aligned}
V(P_g) &= \int_{z\geq z_g^*(S)} \left[P_g(z,S)-\overline{P}_g(S)\right]^2 \frac{dF_z(z)}{1-F_z(z_g^*(S))} \\
&= \int_{z\geq z_g^*(S)} P_g^2\frac{dF_z(z)}{1-F_z(z_g^*)} + \overline{P}_g^2 - 2\overline{P}_g \underbrace{\int_{z\geq z_g^*} P_g\frac{dF_z(z)}{1-F_z(z_g^*)}}_{=\overline{P}_g} \\
&= \int_{z\geq z_g^*(S)} P_g^2\frac{dF_z(z)}{1-F_z(z_g^*)} - \overline{P}_g^2 && \text{(See Equation 10)} \\
&= \frac{\theta}{\theta-2}\overline{P}_g^2 - \overline{P}_g^2 \\
&= \frac{2}{\theta-2}\overline{P}_g^2
\end{aligned}$$

B.4 Manipulation from the Regional to Central Government

We now prove Lemma 3. Consider a manipulation of an applicant from the regional government to the Central Government. In that case there are two conditional that should hold. First, that the application should be "feasible" for the applicant under the Central government i.e., $V_c(z,S')\geq 0$ and second, it should be incentive compatible i.e., $V_c(z,S')\geq V_r(z,S)$. Mathematically, they can be expressed as follows:

$$\begin{aligned}
&V_c(z,S') \approx z\phi(S)\times zq(S) - c_A(S) - c_M(S) \geq 0 && \text{(Individual Rationality)} \\
&V_c(z,S') \approx z\phi(S)\times zq(S) - c_A(S) - c_M(S) \geq bz\phi(S)\times zq(S) - \lambda c_A(S) && \text{(Incentive Compatibility)}
\end{aligned}$$

Re-arranging the IC constraint implies that $(b-1)z^2\phi(s)\psi(s)\leq(\lambda-1)-\tau(S)$, where $\tau(S)=\frac{c_M(S)}{c_A(S)}$. IC is not satisfied as long as $b>\lambda-\tau(S)$ i.e., the costs of manipulation $\tau(S)$ are sufficiently high.

B.5 Manipulation from Central to Regional Government

Consider manipulation of a project from the Central government to the Regional government. The feasibility and incentive compatibility constraints for this condition are as follows:

$$V_r(z,S') \approx bz\phi(S) \times zq(S) - \lambda c_A(S) - c_M(S) \geq 0 \qquad \text{(Individual Rationality)}$$
$$V_r(z,S') \approx bz\phi(S) \times zq(S) - \lambda c_A(S) - c_M(S) \geq z\phi(S) \times zq(S) - c_A(S) \qquad \text{(Incentive Compatible)}$$

IR implies

$$bz^2\phi(S)\psi(S) \geq \lambda + \tau(S)$$

IC implies

$$(b-1)z^2\phi(S)\psi(S) \geq (\lambda - 1) + \tau(S)$$

Re-arranging both the constraints, we can calculate the productivity of the marginal project:

$$\begin{aligned}
z^*_{IR} &= \sqrt{\frac{\lambda + \tau(S)}{b}} \times \frac{1}{\sqrt{\phi(S)\psi(S)}} \\
z^*_{IC} &= \sqrt{\frac{\lambda + \tau(S) - 1}{b-1}} \times \frac{1}{\sqrt{\phi(S)\psi(S)}} \\
z^*_{M} &= \max\{z^*_{IR}, z^*_{IC}\} = \max\left\{\sqrt{\frac{\lambda + \tau(S)}{b}}, \sqrt{\frac{\lambda + \tau(S) - 1}{b-1}}\right\} \times \frac{1}{\sqrt{\phi(S)\psi(S)}} \\
&= \sqrt{\frac{\lambda + \tau(S) - 1}{b-1}} \times \frac{1}{\sqrt{\phi(S)\psi(S)}} = Mz^*_c
\end{aligned}$$

where the penultimate equality comes from the assumption that $\lambda + \tau(S) > b$, which is necessary since we observe positive mass to the right side of the threshold. If $\lambda + \tau(S) \leq b$ then all project to the right of 40 would sort to the left. Lastly, note that since $\tau'(S) > 0$ and $z_c^{*\prime(S)>0}$, it implies that $z_M^{*\prime(S)>0}$ i.e., the threshold productivity to manipulate is increasing in the size of the project. To put it another way, this implies that sorting is strongest for the projects near the threshold and will decrease with increasing size.

C Validation of the Model Assumptions

We provide evidence to validate some of the assumptions and predictions of the theoretical model. First, Equation (5) suggests that the density of applications decreases as a function of size and from Lemma 1, conditional on applying, the approval probability should be increasing in S. Figure B1 uses the universe of projects and shows that the density of projects are decreasing with the size of the project, and the probability that it is approved increases in project size. To formalize the latter insight, we estimate the following regression for a project i in a category c, state s and year t:

$$\mathbf{1}(\text{Approved})_{icst} = \beta \ln(Area)_{icst} + F.E. + \varepsilon_{icst} \tag{18}$$

where $\mathbf{1}(\text{Approved})_{icst}$ takes the value 1 if the project was approved and 0 otherwise and Area_{icst} is the size of the project. We report the results in Table B1. All regressions control for state fixed effects.

In addition, Columns (1) and (3) use category and year fixed effects, while in Columns (2) and (4), we use category-year fixed effects. Since the outcome variable is a discrete binary outcome, in Columns (1) and (2) we estimate a linear probability model, while we estimate a random effects probit model in Columns (3) and (4). We cluster standard errors at the state level. As can be seen, we see that the average probability that a project is approved is robustly increasing with the size of the project.

Figure B1—Density, Approval Rates and Project Size

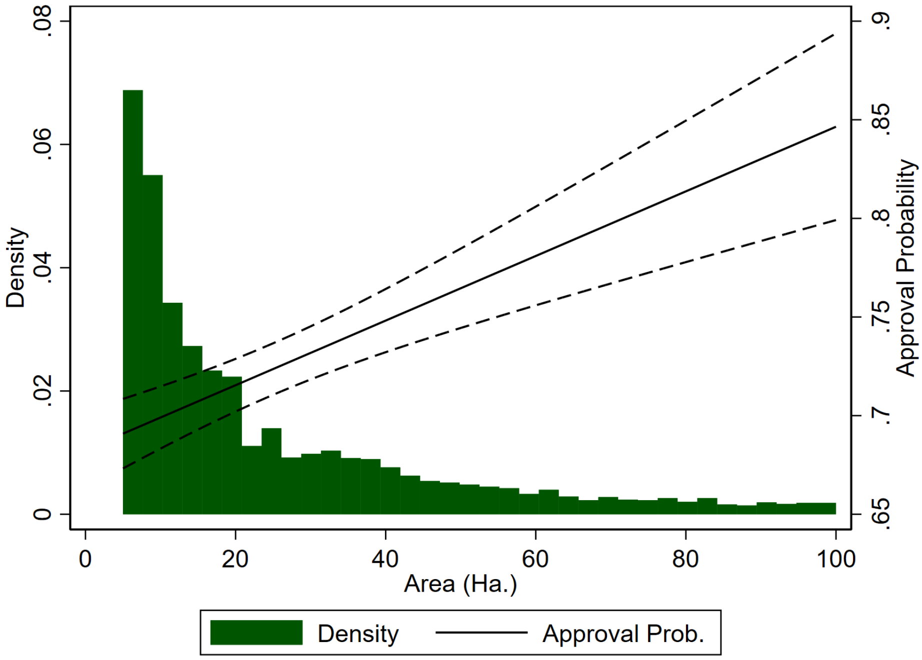

Table B1—Approval Rates and Area

	1(Project Approved)			
	(1)	(2)	(3)	(4)
Ln(Area)	0.080***	0.077***	0.242***	0.232***
	(0.018)	(0.018)	(0.073)	(0.045)
R2	0.08	0.13	.	.
N	2615	2584	2612	2607
State FE	Yes	Yes	Yes	Yes
Year FE	Yes	No	Yes	No
Cat. FE	Yes	No	Yes	No
Cat. x Year FE	No	Yes	No	Yes
Spec.	OLS	OLS	Probit	Probit