Estimating the Effects of Political Quotas Across India using Satellite Imagery

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Abstract

We estimate the effect of electoral quotas in India's state legislatures on the provision of public services to villages. To address endogeneity and selection concerns, we use a geographic discontinuity design, focusing on villages just inside and outside borders that delineate reserved and unreserved constituencies. By comparing villages that are on average highly similar except for reservation status, we estimate the effect of reservation on improving the provision of electricity from 1992 to 2008. Looking nationally, there is no evidence of a significant positive or negative effect of reservation. Yet by examining heterogeneity of the estimated effects across India, we present tentative evidence that the effect of reservation is contingent upon the effects on political participation and competitiveness of the quota regime. Where reservation leads to higher levels of political participation, the overall effects on service provision appear positive.

1 Introduction

Quotas of electoral seats in national and sub-national legislatures are among the most widely used affirmative action programs around the world. Over 100 countries have mandated representation of women and over 30 countries have mandated representation of minorities in their parliaments (Krook & O'Brien 2010). The common motivation for quotas is to ensure some level of representation for groups that lack access and representation in politics, either due to historical exclusion or because of electoral rules that make it difficult for minority groups to win seats. However, the overall effect of electoral quotas remain unclear, especially on the welfare of the marginalized groups quotas are designed to help.

In this paper, we draw on disaggregated data from India to evaluate the effects of electoral quotas on the provision of local public services. Specifically we compare electricity provision in villages located in unreserved state assembly constituencies against villages in constituencies reserved for candidates from Scheduled Caste (SC) groups. Our unit of analysis is the village and we compare data across all of India's states. By analyzing a far broader set of cases than in previous research, we attempt to better understand why prior research has found such contradictory evidence for the effects of reservation.

In general, regressing an outcome of interest on a policy like political reservation is unlikely to yield the causal effect of reservation. Among other difficulties, factors associated with selection into reservation may also be correlated with outcomes of interest. For example, an important determinant of selection into reservation is the concentration of SCs within a constituency. But SC status is also correlated with economic disadvantage, which is likely to influence future outcomes. Thus reservation status of a constituency is unlikely to be randomly determined.

We address this main methodological issue by using a regression discontinuity design in which we exploit a geographical discontinuity. More specifically, we compare outcomes for villages near constituency borders, comparing those just inside a reserved constituency against villages just outside. Since the reservation status changes discontinuously at the border of a reserved and unreserved constituency, villages next to border in unreserved constituencies could serve as a valid counterfactual for villages that are next to the border on the reserved side. So reservation status is determined as if it was random.

While it is reasonable to assume that fixed geographic conditions like local climate, soil quality, ruggedness, and remoteness are all likely to be similar for villages right along a shared border, we show that villages are similar on a wide range of observed covariates. By exploiting this regression discontinuity design, we find that reservation has negligible effects public good provision overall. Public goods access in villages that are just inside the border of reserved constituencies does not differ significantly for villages that just outside. Further, we contend that the effects of reservation depend on its impact on political competitiveness. We present evidence showing that when political participation (as a measure of competitiveness) is diminished, reservation has negative effects on public service provision. By contrast, in states where reserved seats have greater participation rates, reservation can enhance the provision of public services to marginalized villages.

The paper proceeds as follows. The next section reviews the literature on political reservation and quotas in India. We then describe our data, including our measure of electricity provision derived from nighttime satellite imagery. After describing our empirical strategy, we present results that compare outcomes for villages just inside and outside reserved constituency borders. We then document that the effects of reservation vary widely across states, and conclude by showing that effects depend highly on regional political context.

2 Literature Review

The implicit goal of affirmative action policies is to improve the well-being of marginalized sections of society. Yet a vibrant literature finds contradictory evidence for the effects of electoral quotas on the welfare of socially disadvantaged groups. From a theoretical standpoint, the effect of reserved seats for minorities is ambiguous. On the one hand, reservation may enhance political representation, resulting in elected leaders that better understand and cater to the needs of their marginalized constituents. On the other hand, reservation may reduce political competition because of the severe restrictions it places on the pool of eligible candidates. Quotas can attract more low quality candidates to run or make it easier for poorly performing leaders to stay in office. Empirical research on reservation in India has not been able to provide a definitive answer on which of these effects — better representation or weakened competition — are stronger.

Pande (2003) examines the effect of constitutionally-mandated political quotas for SCs and STs in state legislatures in India and finds that mandated political representation increases spending targeted towards these groups. Banerjee & Somanathan (2007), while not explicitly focusing on reservation, report that districts with high proportion SCs (thus more likely to have been reserved), have improved remarkably in access to public goods over the 1970s and 1980s, while STs remain disadvantaged. By contrast, Chin & Prakash (2010) examine the overall effect of mandated representation on poverty in Indian states and find that political reservation reduces poverty for STs but has no effect for SCs.

Additional research has focused on the effects of reservation of village leadership, following the 73rd amendment to the Constitution of India in 1992, which made provisions for reservation of hitherto underrepresented sections, mainly women, SCs, and STs, in the village councils and village chief positions. Arguably, this may constitute the most aggressive policy in a country to establish political quotas for disadvantaged groups. Duflo

(2005) provides a review of research findings of the Indian experiment. She identifies three conditions for a reservation policy to alter the distribution of public goods in favor of the disadvantaged groups. First, the preferences of the reserved groups must differ from the other groups. Second, the identity of the policymaker must affect the distribution of public goods, and policymakers must favor members of their groups. Third, without reservation, members of weaker groups must be underrepresented. She provides evidence that these conditions are true in the Indian case.

Using detailed survey data on the type and location of public goods provided in a district each in two Indian states of West Bengal and Rajasthan, Chattopadhyay & Duflo (2004a, 2004b) find that identity of village chiefs matter. A female village chief provides goods preferred by females. The same is true for chiefs belonging to the SC or ST category. Besley et al. (2004) examine survey evidence from 396 villages across the southern Indian states of Andhra Pradesh, Karnataka, and Tamil Nadu. They find that the likelihood of an SC/ST household getting a public good increases by seven percentage points in a reserved village compared to an unreserved village. Also, a village chief belonging to a seat reserved for SC/ST category allocate more resources towards targeted goods, which they call low spill over goods.

Using a detailed survey on the benefits received from local programs in 16 districts of of the state of West Bengal, Bardhan, Mookherjee & Parra Torrado (2009) find no evidence that a female village chief targets benefits towards female constituents. Moreover, the other marginalized groups, such as SCs and STs are worse off in such villages. In contrast, they find a significant positive effect of SC/ST chief reservation on per capita benefits in the village as a whole, and on intra-village targeting to female headed households, as well as the group (SC or ST) for whom the position is reserved. They also find that the adverse impact of Pradhan reservations for women on intra-village share of SC/ST groups was significantly smaller in villages more susceptible to elite capture (e.g., with greater land inequality and higher poverty within SC/ST groups), possibly due to election of inexperienced women disturbing the traditional capture-clientelism equilibrium. However, they concede that it is not clear what the effect would be in longer run. Munshi & Rosenzweig (2010) argues that randomization of reserved seats on a village council can enhance caste discipline and result in higher quality candidates.

Despite this string of findings, Dunning & Nilekani (2010) highlight how endogeneity can bias empirical estimates of quotas' effects. Exploiting the fact that reservation for village council presidencies rotate over time, they use a regression discontinuity design to examine 200 village councils in Karnataka and find no strong effect of reservation on distributional outcomes. Drawing upon a similar implementation of randomized reservation of local legislature seats for women in Mumbai, Bhavnani (2009) finds that reservation increases female participation and re-election rates even after reservation is removed.

On the other hand, reservation may improve outcomes if the screening mechanism results in elected officials that better represent constituent preferences. The way in which these countervailing effects interact differ across India's states. In some areas of India, reservation has helped foster the rise of politically powerful low-Caste parties. While in other areas, there remains no independent political movement organized around Caste.

One factor that affects these pathways is the relative size of groups in the political landscape and how it shapes the electoral viability of different group identities (Posner 2005, Eifert, Miguel & Posner 2010). The share of SCs varies widely across India's states. Where SCs are too small to make up a significant voting bloc, it is less likely that Caste-based identities will emerge as the most politically salient axis of cleavage. Yet, in states with larger SC populations, the power of a coordinated voting bloc can foster stronger ethnic identities (Chandra 2004, Jaffrelot 2003). This has occurred in Uttar Pradesh, where the politicization of Caste has dominated electoral party politics. With strong voting support from Scheduled Castes, the Bahujan Samaj Party (BSP) has been the strongest party of the last decade.

3 Reservation in India

Political reservation for Scheduled Castes and Scheduled Tribes was mandated in 1950 in the Constitution of India, Article 332. The mandate required that a share of seats in the lower house of the Parliament (Lok Sabha) and state legislative assemblies (Vidhan Sabha) were to be reserved for SC or ST candidates only. While the entire electorate may participate in the selecting their preferred candidate, only those candidates belonging to the reserved group may compete in the election. Though SCs and STs can stand for election in unreserved constituencies, some reports suggest that virtually no seats have ever been won by SC or ST candidates in unreserved constituencies (Chin & Prakash 2010).

The Constitutional provision requires that the proportion of seats reserved for Scheduled Castes and Tribes in each elected body be roughly equal to their share in the population of that state. For example, if Scheduled Castes constitutes 25 percent of the population of a state, then one-fourth of the seats in the state assembly must be reserved for them.

The task of reservation is undertaken by the independent Delimitation Commission, which is also responsible for reapportionment of electoral constituencies. Under the Constitution of India, the Delimitation Commission is a high power body whose orders have the force of law and cannot be called in question before any court. The commission is headed by the chief election commissioner, who is the head of the semi-autonomous body for conducting elections, and two judges or ex-judges from the Supreme Court or High Court. The Commission is generally constituted following the decennial census. Since independence, India has formed Delimitation Commissions in the following years: 1952, 1963, 1972, and 2002. The 42nd Amendment to the Constitution in 1976 fixed constituency boundaries until after the 2001 Census. This was motivated by the aim to ensure that aggressive family-planning initiatives enacted in the 1970s (to control population growth) would not adversely affect political representation in the Lok Sabha and Vidhan Sabhas, as population share is the main determinant of the number of seats allocated across each state. Following the 2001 Census, a new delimitation exercise was conducted for the first time in three decades. Beginning in 2008, elections were conducted under the new boundaries. Thus a key feature of the Indian electoral map is that boundaries and reservation status of seats have been constant and unchanged at the state and federal levels from the 1970s to 2008.

On arrival of fresh Census data, the Delimitation Commission decides on changing the total number and boundaries of state legislative seats. The general rule is that each constituency with in a state should have roughly equal population. Once the total number and boundaries of seats is decided, a percentage of those are reserved for the Scheduled Castes and Scheduled Tribes. This share is roughly equal to the population share of each group in that state. This fixes the number of reserved seats in the state. These seats are then allocated to each district (geographical division below state) within the state, again equal to the share of population residing in each state. The selection of reserved seats is done within district. The constituencies within a district are arranged in descending order of proportion of SCs or STs. The constituency with the largest proportion of SCs or STs is reserved first, proceeding down the ordered until the number of reserved seats allocated to that district has been met. A final additional rule is that the seats reserved for SCs, but not STs, be geographically dispersed.

Together, these rules imply that the likelihood that a village will find itself in a reserved constituency depend primarily on the concentration of SCs or STs at higher levels of geography: the state, district, and assembly constituency level. An individual village's characteristics, including the number of its villagers that are SC or ST, are in fact less important predictors. We exploit this institutional feature of reservation to identify villages alongside constituency borders that are likely to be highly similar in key respects except that some are in reserved areas and some are not.

4 Empirical Strategy

Consider that an outcome observed in a village, say light output, is related to the reservation status of its constituency as in the following model.

$$Light_{ijst} = \alpha + \beta * SC_{ijs} + \delta * X_{jst} + \varepsilon_{ijst} \tag{1}$$

where $Light_{ijst}$ is light output for village i in constituency j in state s in year t. SC_{ijs} is an indicator variable for treatment, which is 1 if a constituency j in state s is reserved for SC and 0 if the constituency is not reserved, i. e. it is a General constituency. Note that reservation status is time invariant, as it was constitutionally fixed between 1976 and 2008, which covers our data period. Also, reservation status does not vary within a constituency. So, all villages i within a constituency j have the same reservation status. Lastly, X_{ijst} are time-variant predetermined characteristics of constituency j in state s in year t and ε_{ijst} is the stochastic error term.

If reservation status was randomly determined, $E[\varepsilon_{ijst} \mid SC_{ijs}, X] = E[\varepsilon_{ijst} \mid SC_{ijs}] = 0$. As such, β is the true effect of reservation and equals the difference in the average light output of villages in reserved and unreserved constituencies.

$$E[Light_{ijst} \mid SC_{ijs} = 1] - E[Light_{ijst} \mid SC_{ijs} = 0] = \beta. \tag{2}$$

However, reservation status of a constituency is not randomly determined and depends on various demographic and socioeconomic characteristics. As described above, the likelihood that a village is assigned to a reserved constituency depends on the concentration of

SCs in the state (which determines the total number of SC seats), in the district (which determines how many seats within the district will be reserved), and the relative rank in SC concentration of the constituency. This suggests that the concentration of SC voters within a village is likely to be an imperfect predictor of whether it is in a reserved constituency or not. Nevertheless, it is highly plausible that a village in a reserved constituency is not comparable to a village in an unreserved constituency.

Since reservation is not randomly assigned, differences in outcomes might be a result of reservation but could also be a result of characteristics that differ systematically across reserved and unreserved villages. We could easily control for any observed characteristics that are different and estimate the partial effect of reservation status. It is likely that there is unobserved heterogeneity across villages, i. e. villages differ systematically on characteristics that are unobservable, and the condition $E[\varepsilon_{ijst} \mid SC_{ijs}, X] = 0$ is not true. The model in (1) will suffer from omitted variable bias and we have

$$\begin{gathered} E[Light_{ijst} \mid SC_{ijs} = 1, X] - E[Light_{ijst} \mid SC_{ijs} = 0, X] = \\ \beta + E[\varepsilon_{ijst} \mid SC_{ijs} = 1, X] - E[\varepsilon_{ijst} \mid SC_{ijs} = 0, X] \end{gathered} \tag{3}$$

We exploit a discontinuity in geographical location of villages that are close to the border between a reserved constituency and an unreserved constituency (for a related approach, see **?** and **?**). At the border separating these constituencies, reservation status changes discontinuously. We compute the Euclidean distance (in kilometers) of each village from the nearest border between a reserved and an unreserved constituency and postulate that as this distance from the border gets smaller, we have villages on either side of the border that are, on average, comparable to each other. In the limit as the distance approaches 0, villages in the reserved side of the border are identical to villages on the unreserved side of the border in all predetermined characteristics except in their reservation status. More formally, define reservation status as follows

$$SC_{ijs} = 1 \; if \; D_{ijs} > 0 \tag{4}$$
$$= 0 \; if \; D_{ijs} < 0,$$

where D_{ijs} is the Euclidean distance of village i in constituency j in state s from the nearest border between a reserved and an unreserved constituency. By definition, distance at the border is zero. For villages that are in reserved constituencies distance is positive and for villages that are in unreserved constituencies distance is negative. In this setup, while distance is continuously distributed, reservation status changes discontinuously at the border, i. e. at $D_{ijs} = 0$. This geographical discontinuity design compares villages that are within an arbitrary close proximity of the border.

$$\begin{aligned} E[Light_{ijst} \mid 0 < D_{ijs} \leq \lambda, X] - E[Light_{ijst} \mid -\lambda \leq D_{ijs} < 0, X] = \\ \beta + E[\varepsilon_{ijst} \mid 0 < D_{ijs} \leq \lambda, X] - E[\varepsilon_{ijst} \mid -\lambda \leq D_{ijs} < 0, X]. \end{aligned} \tag{5}$$

where λ measures proximity to the border between a reserved and an unreserved constituency. In the limit as λ goes to zero or as we examine villages that are closer to the border, the second term in (4) reflecting bias due to unobserved heterogeneity between reserved and unreserved villages becomes smaller.

$$\lim_{\lambda \to 0^+} E[Light_{ijst} \mid 0 < D_{ijs} \leq \lambda, X] - \lim_{\lambda \to 0^-} E[Light_{ijst} \mid -\lambda \leq D_{ijs} < 0, X] = \beta], \tag{6}$$

which is simply the difference in the average light output between villages that are right next to the border on either side.

The above framework relies on much weaker assumptions on behavior of the unobservable variables than is true for other quasi-experimental approaches that assume selection-on-observables. While reservation status is a discontinuous function of distance from the border, unobserved characteristics are assumed to vary continuously with distance, i. e. the conditional density function of the error term given distance from the border, $g(\varepsilon|D)$ is continuous.

5 Data

Our dataset is comprised of observations for the nearly 600,000 villages in India. All villages are located in one of 4,002 state assembly constituency seats. Of these seats, 542 (14%) seats are reserved for SCs and 508 (13%) are reserved for STs. Table 1 shows the distribution of seats by reservation status across India. These seats are mapped in Figure 1. Our research design aims to evaluate differences in electricity provision among villages right at the border of reserved and unreserved constituencies. Figure 2 highlights these border zones.

We are particularly interested in the reservation of seats in the state house because of the significant role members of the legislative assembly (MLAs) play in directing spending for local and regional development. In India's federal system, most public service provision is the responsibility of state governments, and MLAs are thus the elected officials with the most direct links to the state purse. While local village councils can play a role in determining distributional outcomes within their villages, local councils are typically unable to afford large projects like paved road construction or electrification on their own. Even powerful locals councils are reliant on their MLAs to direct infrastructure projects and spending to their villages. This is especially true for electricity, our primary outcome of interest.

Scheduled Castes make up about 15% of the Indian population and are geographically dispersed across India, typically residing in villages alongside other castes. By contrast, Scheduled Tribes, who make up 7.5% of the population, tend to be spatially concentrated with many villages inhabited by a single tribe. Given these patterns, we expect our research design to yield valid causal inferences when comparing villages alongside borders for SC reserved seats than for ST seats. As a result, we focus most of the analysis on the effects of SC reservation.

5.1 Dependent Variable

Our measures of electrification are derived from satellite imagery of the earth at night. The imagery are consistently recorded, enabling comparisons of changes over time. By contrast, data on access to public services recorded in the Census are difficult to compare over time, since villages cannot be easily matched across Censuses. Moreover, definitions are variable, including for electricity provision, and census data is only available every 10 years.

The satellite images come from the Defense Meteorological Satellite Program's Operational Linescan System (DMSP-OLS), a set of military weather satellites that have been flying since 1970 in polar orbit recording high resolution images of the entire earth each night between 20:00 and 21:30 local time. Captured at an altitude of 830 km above the earth, these images reveal concentrations of outdoor lights, fires, and gas flares at a fine resolution of 0.56 km and a smoothed resolution of 2.7 km. Beginning in 1992, all DMSP-OLS images were digitized, facilitating their analysis and use by the scientific community. While daily images are available, the primary data products used by most scientists are a series of annual composite images. These are created by overlaying all images captured during a calendar year, dropping images where lights are shrouded by cloud cover or overpowered by the aurora or solar glare (near the poles), and removing ephemeral lights like fires and other noise. The result is a series of images covering the globe for each year from 1992 to 2009 (Elvidge et al. 1997, Imhoff et al. 1997, Elvidge et al. 2001). Since the DMSP program may have more than one satellite in orbit at a time, some years have two annual images created from composites from each satellite, resulting in a total availability of 30 annual composite annual images. Images are scaled onto a geo-referenced 30 arc-second grid (approximately 1 km^2). Each pixel is encoded with a measure of its annual average brightness on a 6-bit scale from 0 to 63. Further image processing is performed to identify which pixels are consistently lit over time, dropping light values from pixels with unstable light signatures over time. This results in an image of time stable night lights. For this project, we use the average annual lights product to minimize the sensitivity of our results to image processing algorithms.

Compared with traditional data on energy production and consumption, the satellite image explicitly reveals the geographic distribution of electrical power, providing a clearer picture of the beneficiaries of public infrastructure across space. Moreover, since the satellite images are captured electronically through an automated process, the data have the virtue of being unbiased by human factors, consistently recorded, and complete with no missing data. Other studies document that satellite imagery of the earth at night correlates highly with local level electricity use in the developing world (**?**, **?**).

For each village, we measure the log level of light output (Log Light), log differences of light output in the current year over the previous year (Growth of Light), and an indicator variable for any light output as our dependent variables. All these variables are annual observations over the period from 1992 to 2008 for each village in India. Figures **??** and **??** illustrate how light output has changed over this timeframe. The emission of light at night reveals both the presence of electrical infrastructure and the regular flow of electrical power converted into outdoor lighting at night. Outdoor lighting is meaningful because it is a useful application of electricity with broad public benefits and suggests contexts in which electricity provides positive externalities.

We use GIS software to spatially match and extract average annual nighttime light output for the nearly 600,000 villages in India. We also overlay a map of India's 4,000 state assembly constituencies to identify the state assembly constituency in which each village is located.[1] Figure 3 illustrates how distance to relevant borders can be used to select proximate villages for comparison. In the figure, which shows the northern state of Uttar Pradesh, only villages within 2 kilometers of a border between a reserved and unreserved seat are highlighted.

6 Results

6.1 Validity of RDD

The key premise on which our RD design is based is that villages are likely to be very similar on either side of the borders of a reserved constituency, i. e. the characteristics of the villages vary continuously with distance from the border between a reserved constituency and unreserved constituency (henceforth simply referred to as the border). In other words, near constituency borders, we suggest that assignment of a village into reservation status is determined as if there were a random assignment.

In Figure 5, we examine the continuity of various village characteristics with respect to the distance from the border. In Panel A, we plot the natural log of light in 1992, the first year of our sample period, against distance from the border using two methods: local averages and local linear regression. Villages in reserved constituencies are plotted as having positive distances and those with negative values are in unreserved constituencies. Local averages plot the average light output in each 1 Km interval of the distance. There is no apparent discontinuity in light output in 1992. We also fit a local linear regression

[1]The assembly constituency map and village point location data come from ML Infomap.

of log light output in 1992 on distance separately on either side of the border to examine any discontinuity in prior light output. The local linear regression is fit using a triangular kernel and an optimal bandwidth as suggested by (**?**). We also plot the 95% confidence intervals for local linear curve. The local linear plot also suggests that light output in 1992 is a continuous function of distance form the reserved border.

In Panel B we plot an indicator variable for being lit in 1992 against the distance from the border. The indicator variable is 1 if a village emits any positive light output and 0 otherwise. Thus, the plot gives the probability a village is lit. Both local averages and local linear plots suggest that the probability of being lit does not differ between villages in reserved constituencies and those in unreserved constituencies.

As a further check, we compare villages reserved for the SC and unreserved villages on a range of observed covariates available from the 2001 village-level census data (the census year for which we could get consistent data) in panels (C)-(H) of Figure 5 using both local averages and local linear regressions.[2] These plots also show that villages are indeed more similar the closer you get towards the reserved constituency border.

In addition to the visual evidence, Table 2 reports the point estimates of the differences between various village characteristics. In columns (1)-(3), we compare all reserved villages to all unreserved villages. Villages in reserved constituencies, on average, have significantly lower light output in 1992, smaller number of households, are less populated, and have smaller proportion of literate, female population, employed and cultivators compared to villages in unreserved constituencies. These differences would suggest that a comparison of all reserved villages with unreserved villages is fraught with bias that arises due to heterogeneity between such villages. The differences between reserved and unre-

[2]There are some caveats, however. Our comparison is based on 2001 Census village characteristics, and not on pre-treatment characteristics. This would require data from the 1971 Census to identify characteristics prior to the last delimitation in 1976. In fact, since villages may have been reserved even prior to that delimitation, earlier data at Independence would be necessary. Such historical data do not exist in electronic format and are unfortunately inaccessible.

served villages are smaller, although still significant, in columns (4)-(6) where we only consider villages within 10 km of the border.

The RD Design suggests that these differences would become insignificant in the limit, i. e. , right at the border. These differences are reported in column (7) in which we fit local linear regression on either side of the border using a triangular kernel and an optimal bandwidth (h). All the differences in the characteristics of villages are insignificant. The results are the same with alterative choices of bandwidth, which is half the optimal bandwidth in column (8) and twice the optimal bandwidth in column (9).

An additional concern is that citizens can move across borders once reservation decisions have been made. However, given the stability and deep family links that tie Indians to their villages, we believe that such Tiebout sorting does not frequently occur in rural areas. If such Tiebout sorting were to occur, we would expect that SC residents would be the most likely to move. An SC resident living in an unreserved constituency might consider it advantageous to move across the border into a reserved constituency. We might therefore expect a discontinuity in proportion SC right at the border, as SC citizens move into nearby reserved constituencies. We do not see this in our data. In Figure 6, we plot the proportion SC against distance to a reserved border. The proportion of SC citizens is very similar in villages on either side of a reserved constituency border.

6.2 The RDD Estimates of Reservation

Using our boundary maps, we proceed to analyze differences in light output between villages in reserved (SC) and non-reserved constituencies on the pooled village data over the 1992-2008 period. Panel a of Figure 7 plots local averages (over each 1 Km) and local linear regressions of the log of light output on both sides of the border of reserved constituencies. We use a triangular kernel and calculate optimal bandwidths as proposed by **?**. As above, villages in reserved constituencies are plotted as having positive distances and those with negative values are in unreserved constituencies. The light output in villages in reserved constituencies is indistinguishable from light output in villages in unreserved constituencies right next to the border as there is no visible discontinuity at the border. The plot also suggests that a comparison of an average village in reserved constituency with an average village in unreserved constituency would artificially suggest a negative effect of political reservation as the light output is sloping downwards for reserved villages away from the border. These villages are however not comparable to villages in unreserved constituencies.

Panel b plots the growth of light output using local averages and local linear regression. There does not appear to be any discontinuity in growth of light at the border. In panel C we plot probability of being lit as the dependent variable is an indicator variable for being lit, which is 1 if a village emits any light and 0 if it emits no light. Again, reservation seems to have no effect on the probability of being lit. Overall, the findings suggest that there is no substantial effect of reservation for Scheduled Castes on the provision of electricity across India over the last two decades.

In Table 3 we report the point estimates of the differences in the means of various light variables. In columns (1)-(3), we consider all villages. Villages in reserved constituencies have significantly lower light output, lower growth rate of light output, and smaller probability of being lit than villages that are in unreserved constituencies. Columns (4)-(6) consider only the villages that are within 10 kilometers of the border. In this sample, villages in the reserved constituencies continue to have lower light output, lower growth rate of light output, and smaller probability of being lit than villages in the unreserved constituencies. Column (7) reports regression discontinuity estimates of these differences at the border. There are no significant differences in light variables between villages right around the border.

Columns (8)-(9) report the estimated size of the discontinuity in the light variables using alternative choices of bandwidth. Specifically, we consider bandwidths that are half (in column (8)) and double (in column (9)) the optimal bandwidth size. Changing the bandwidth does not change our finding that there is no significant effect of reserving seats for the SC candidates on provision of electricity.

6.3 Alternative Outcome Variables

To explore whether our estimates of a null effect of reservation are robust to our choice of outcome variables, we also examine differences in access to public services as reported in the 2001 Census. The census village amenities data are limited in that they only indicate whether a village has access to a public good (education, paved road, health and so on) or not. It does not report the quality of these services or whether the services are broadly available across the community. Nevertheless, the data provide a useful way to check whether the satellite-based findings are mirrored in official data codings.

We consider access to the following public goods for which data are generally complete: power supply, health facility, education facility, paved approach road, drinking water facility, and post and telegram facility. These are some of the most important public goods from a political salience viewpoint.

Each of the Panels in Figure 8 plots an indicator variable that is 1 if a village has access to a specific public good and 0 otherwise against the distance from the border. Thus, both local averages and local linear plots estimate the probability a village has access to that public good. The plots suggest that there is no significant difference between villages on either side of the reserved border. Consistent with our satellite-based results, a village in a reserved constituency is as likely to have access to a public good as a village just across the border in an unreserved constituency. These results suggest that our finding above of no effect of reservation on light output is not an artifact of the outcome used. The effect is not significant for a range of public amenities.

7 Heterogeneous Treatment Effects and Political Competitiveness

While the overall effect of reservation for SCs appears to be neutral across India, our data reveal that there is substantial variation in the effect across the country. These divergent results imply that there is no universal effect of reservation, but rather that its impact depends largely on local context and contingent political response. More specifically, we examine if the effect of reservation of seats varies with constituency specific political factors, such as measures of voter participation and electoral competitiveness.

In the spirit of the argument above, we report in Table 4 the results of how the effect of reservation varies with constituency-specific measures of turnout, margin of victory, and whether the incumbent is a member of the ruling coalition. We consider pooled data of villages that are within 2 Kilometers of a border with a reserved (SC) seat as these villages are more likely to be comparable to each other than villages that are further from the border. We include state fixed effects that would account for any state-specific time-invariant characteristics, such as attitudes towards light usage and distance to the electric grid and so on, year fixed effects that represent common time trends across villages, such as the technological changes nationally that affect light output similarly in all villages, and state-specific time trends that capture secular trends in light output across different states and for other state-level changes. The standard errors are clustered at the constituency level.

In columns (1)-(3), the dependent variable is log of light output. In column (1) we interact the dummy variable for seats reserved for SC candidates with the natural log of percentage of voters who voted. The effect of reservation for villages around the border varies negatively and significantly. This suggests that while there is a null or negative overall effect of reservation on light output, there is nevertheless a positive relationship between turnout and light output in reserved seats. This is consistent with evidence that the mobilization of lower caste voters and parties, such as the Bahujan Samaj Party (BSP) in Uttar Pradesh, has yielded positive impacts in some areas during the period under consideration in our paper. But where mobilization of voters in reserved seats is low, there are no positive impacts on electricity outcomes. Similar results are seen in columns (4) and (7) that examine growth of light output and probability of being lit. Interaction effects with the natural log of margin of victory and indicator variable for being a member of the ruling coalition are not significant.

Since the reservation status is fixed over the sample period, in Table 5 we average the entire sample over the period 1992-2008. The effects however are largely the same as we find above in Table 4. The effect of reservation varies positively with and significantly only with turnout.

8 Conclusion

We use a geographic discontinuity design to overcome the difficulties in using observational data to estimate the treatment effect of political reservation. By comparing villages just inside a reserved state assembly constituency border with villages just outside, we demonstrate that reservation has a negligible effect on average across India. However, by unpacking the data and looking within India's regions, we show that the effect is actually highly variable, swinging from positive in many states to negative in others.

These findings highlight one of the pitfalls of estimating and interpreting treatment effects in both experimental and quasi-experimental research. While sample size and other data limitations lead analysts to focus on identifying average treatment effects, ignoring the compositional variation underlying those effects can be treacherous. Our first look at the data suggested a null average treatment effect. Yet in fact, that average null effect may nevertheless be comprised of heterogeneous effects varying from positive to negative across India. We present tentative evidence suggesting that the effect of reservation depends on how political participation and competition has diminished as a result of the policy. When the response has been the politicization of Caste and the formation of narrow Caste based parties, competition is more likely to have suffered. But where Scheduled Caste interests have been incorporated into the platforms of broad based parties, reserved seats have remained as competitive as in unreserved areas.

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Table 1: State Assembly Constituency Seats by Category

State	Unreserved	Res(SC)	Res(ST)	Total Seats
Andhra Pradesh	247	38	9	294
Arunachal Pradesh	1	0	59	60
Assam	101	8	16	125
Bihar	204	39	0	243
Chhattisgarh	51	9	30	90
Delhi	57	13	0	70
Goa	39	1	0	40
Gujarat	145	13	24	182
Haryana	73	17	0	90
Himachal Pradesh	50	15	3	68
Jharkhand	44	9	28	81
Karnataka	197	25	2	224
Kerala	126	12	2	140
Madhya Pradesh	163	33	34	230
Maharashtra	248	18	22	288
Manipur	39	1	20	60
Meghalaya	4	0	56	60
Mizoram	2	0	38	40
Nagaland	1	0	59	60
Orissa	93	22	32	147
Punjab	88	29	0	117
Rajasthan	144	33	23	200
Sikkim	18	2	12	32
Tamil Nadu	190	42	2	234
Tripura	36	7	17	60
Uttar Pradesh	315	88	0	403
Uttarakhand	55	12	3	70
West Bengal	218	59	17	294
Total	2,952	542	508	4,002

Table 2: Differences in Means and at Discontinuity: Continuity Checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All Villages			**Villages within 10 Km**			**RDD**		
Dependent Variable	SC	General	Diff	SC	General	Diff	h	h/2	2h
Log Light in 1992	0.71	0.75	-0.045***	0.74	0.75	-0.016***	0.0219	0.02	0.02
	[0.92]	[0.94]	(0.0034)	[0.93]	[0.95]	(0.0040)	[0.0499]	[0.06]	[0.05]
Probability Lit in 1992	0.38	0.41	-0.021***	0.40	0.40	-0.0014	0.008	0.013	0.011
	[0.49]	[0.49]	(0.0018)	[0.49]	[0.49]	(0.0021)	[0.028]	[0.034]	[0.025]
# of Households	233.0	253.1	-20.1***	235.9	239.2	-3.25**	3.0521	6.89	0.41
	[355.0]	[399.2]	(1.42)	[356.3]	[380.6]	(1.58)	[11.0865]	[11.12]	[10.97]
Total Population	1271.8	1363.6	-91.8***	1290.5	1299.2	-8.69	-4.4496	6.74	-9.37
	[1809.9]	[2004.7]	(7.16)	[1821.4]	[1914.9]	(8.01)	[56.0010]	[56.69]	[54.63]
Proportion Literate	0.48	0.48	-0.0060***	0.48	0.48	0.0042***	0.0009	0.001	0.001
	[0.16]	[0.17]	(0.00060)	[0.16]	[0.17]	(0.00070)	[0.0120]	[0.02]	[0.01]
Proportion Female	0.48	0.49	-0.0022***	0.48	0.49	-0.0019***	-0.0020	-0.001	-0.001
	[0.041]	[0.041]	(0.00015)	[0.041]	[0.041]	(0.00017)	[0.0026]	[0.001]	[0.001]
Proportion Employed	0.42	0.44	-0.013***	0.42	0.43	-0.0080***	0.0034	-0.001	-0.001
	[0.13]	[0.13]	(0.00048)	[0.13]	[0.13]	(0.00057)	[0.0108]	[0.01]	[0.01]
Proportion Cultivator	0.16	0.16	-0.0018***	0.16	0.15	0.0034***	0.0052	0.001	0.001
	[0.12]	[0.12]	(0.00044)	[0.12]	[0.12]	(0.00050)	[0.0080]	[0.01]	[0.01]
Obs.	93,079	405,050		82,437	169,255			461,347	

Columns (1)-(3) compare all reserved (SC) villages with all unreserved (General) villages. Columns (4)-(6) compare all reserved (SC) villages with all unreserved (General) villages that are within 10 Km of the border of a reserved constituency. GDD estimates in column (7) give the estimates of the size of discontinuity in the dependent variables between SC and General villages at the border, i.e., a distance of 0 from the border of a reserved constituency. The discontinuity is estimated by fitting a local linear regression on either side of the border using a triangle kernel and an optimal bandwidth (h) as suggested in Imbens and Kalyanaraman (2012). Columns (7) and (8) report the estimates of the size discontinuity for half the optimal bandwidth (h/2) and for double the optimal bandwidth (2h), respectively. Standard errors are clustered at the constituency level and given in brackets. The values with *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 3: Differences in Means and at Discontinuity: Main Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All Villages			**Villages within 10 Km**			**GDD**		
Dependent Variable	SC	General	Diff	SC	General	Diff	h	h/2	2h
Log Light	1.01	1.10	-0.092***	1.04	1.08	-0.047***	-0.0015	0.02	-0.03
	[0.98]	[0.98]	(0.00092)	[0.98]	[1.00]	(0.0011)	[0.0643]	[0.09]	[0.06]
Growth of Light	2.02	1.97	0.057	2.01	1.85	0.16**	0.1102	0.01	0.10
	[59.1]	[58.4]	(0.055)	[59.3]	[59.0]	(0.066)	[0.3108]	[0.35]	[0.31]
Probability Lit	0.54	0.59	-0.049***	0.56	0.57	-0.019***	-0.0134	0.001	-0.01
	[0.50]	[0.49]	(0.00046)	[0.50]	[0.49]	(0.00055)	[0.0271]	[0.03]	[0.02]
Obs.	1,477,549	6,279,362		1,294,285	2,508,690			7,261,272	

Columns (1)-(3) compare all reserved (SC) villages with all unreserved (General) villages. Columns (4)-(6) compare all reserved (SC) villages with all unreserved (General) villages that are within 10 Km of the border of a reserved constituency. GDD estimates in column (7) give the estimates of the size of discontinuity in the dependent variables SC and General villages at the border, i.e., a distance of 0 from the border of a reserved constituency. The discontinuity is estimated by fitting a local linear regression on either side of the border using a triangle kernel and an optimal bandwidth (h) as suggested in Imbens and Kalyanaraman (2012). The optimal bandwidth (h) is 0.6, 3.5, and 0.86 for local linear regressions of Log Light, Growth of Light and Probability Lit. Columns (7) and (8) report the estimates of the size discontinuity for half the optimal bandwidth (h/2) and for double the optimal bandwidth (2h), respectively. Standard errors are clustered at the constituency level and given in brackets. The values with *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 4: Reservation and Interaction Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Log Light			Growth of Light			Probability Lit	
SC	-0.294**	0.024	0.029	-0.861	0.166	-0.244	-0.955**	0.085	0.105
	[0.135]	[0.033]	[0.035]	[1.415]	[0.400]	[0.411]	[0.410]	[0.090]	[0.097]
SC × Log Turnout	0.005**			0.017			0.018***		
	[0.002]			[0.021]			[0.007]		
SC × Log Margin		0.001			0.002			0.004	
		[0.001]			[0.026]			[0.004]	
SC × Ruling party			0.019			0.732			0.052
			[0.031]			[0.580]			[0.088]
Log Electorate Size	0.637***	0.647***	0.646***	-2.320***	-2.289***	-2.289***	1.296***	1.364***	1.363***
	[0.084]	[0.084]	[0.084]	[0.748]	[0.740]	[0.744]	[0.249]	[0.246]	[0.246]
Log Turnout	-0.097	0.030	0.030	1.460**	1.861***	1.868***	-0.069	0.450*	0.453*
	[0.063]	[0.056]	[0.056]	[0.694]	[0.607]	[0.607]	[0.289]	[0.247]	[0.246]
Log Margin	-0.007	-0.011	-0.007	-0.052	-0.058	-0.053	-0.021	-0.031	-0.019
	[0.007]	[0.007]	[0.007]	[0.126]	[0.139]	[0.125]	[0.019]	[0.021]	[0.019]
Ruling Party	0.048***	0.046***	0.039*	0.321	0.316	0.005	0.134***	0.128***	0.106*
	[0.017]	[0.017]	[0.021]	[0.309]	[0.310]	[0.388]	[0.046]	[0.046]	[0.059]
Method		OLS			OLS			Logit	
R^2	0.33	0.33	0.33	0.09	0.09	0.09	0.22	0.22	0.22
N	943,539	943,539	943,539	886,168	886,168	886,168	942,376	942,376	942,376

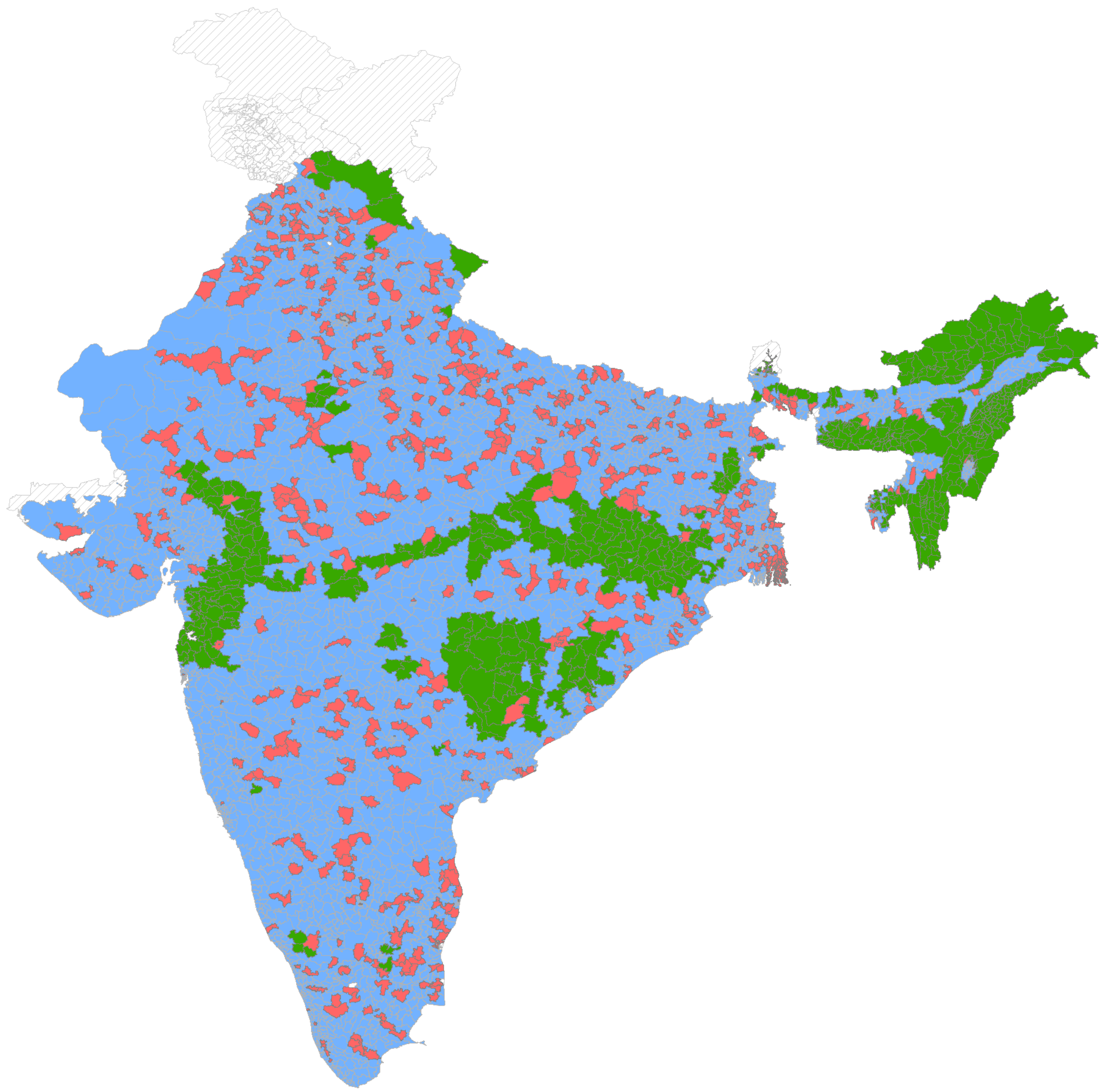
The sample for above regressions is all villages within 2 Kilometers of the reserved border over the period 1992-2008. The dependent variable in columns (1)-(3) is the natural logarithm of light. In column (4)-(6) it is the log differences in light in current over the previous year. In column (7)-(8), the dependent variable is an indicator variable that is 1 if village emits any light and 0 otherwise. SC is a dummy variable that takes a value of 1 for constituencies that are reserved for the Scheduled Castes (SC) and 0 for unreserved (General) constituencies. All regressions include state and year fixed effects and state-specific time trends. Standard errors are clustered at the constituency level and given in brackets. The values with *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 5: Reservation and Interaction Effects: Sample Average

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Log Light			Growth of Light			Proportion of Lit Villages	
SC	-1.549**	0.002	0.015	-4.764	-0.086	0.141	-0.735*	0.002	0.013
	[0.789]	[0.087]	[0.069]	[4.445]	[0.630]	[0.506]	[0.383]	[0.042]	[0.035]
SC × Log Turnout	0.395**			1.209			0.189**		
	[0.190]			[1.065]			[0.092]		
SC × Log Margin		0.038			0.148			0.021	
		[0.040]			[0.275]			[0.019]	
SC × Ruling party			0.105			0.122			0.051
			[0.101]			[0.737]			[0.051]
Log Electorate Size	0.831***	0.857***	0.857***	-0.625	-0.548	-0.542	0.304***	0.316***	0.316***
	[0.101]	[0.099]	[0.099]	[0.611]	[0.604]	[0.605]	[0.048]	[0.047]	[0.047]
Log Turnout	0.095	0.327	0.326	0.050	0.758	0.761	0.123	0.234**	0.233**
	[0.253]	[0.205]	[0.205]	[1.203]	[0.929]	[0.930]	[0.128]	[0.103]	[0.103]
Log Margin	-0.021	-0.033	-0.020	-0.104	-0.154	-0.100	-0.012	-0.018*	-0.011
	[0.020]	[0.022]	[0.020]	[0.137]	[0.159]	[0.138]	[0.010]	[0.011]	[0.010]
Ruling Party	0.105**	0.101**	0.060	-0.661*	-0.675*	-0.720*	0.052**	0.050*	0.030
	[0.051]	[0.051]	[0.059]	[0.372]	[0.371]	[0.429]	[0.026]	[0.026]	[0.030]
R^2	0.38	0.38	0.38	0.19	0.19	0.19	0.35	0.35	0.35
N	60,198	60,198	60,198	60,198	60,198	60,198	60,198	60,198	60,198

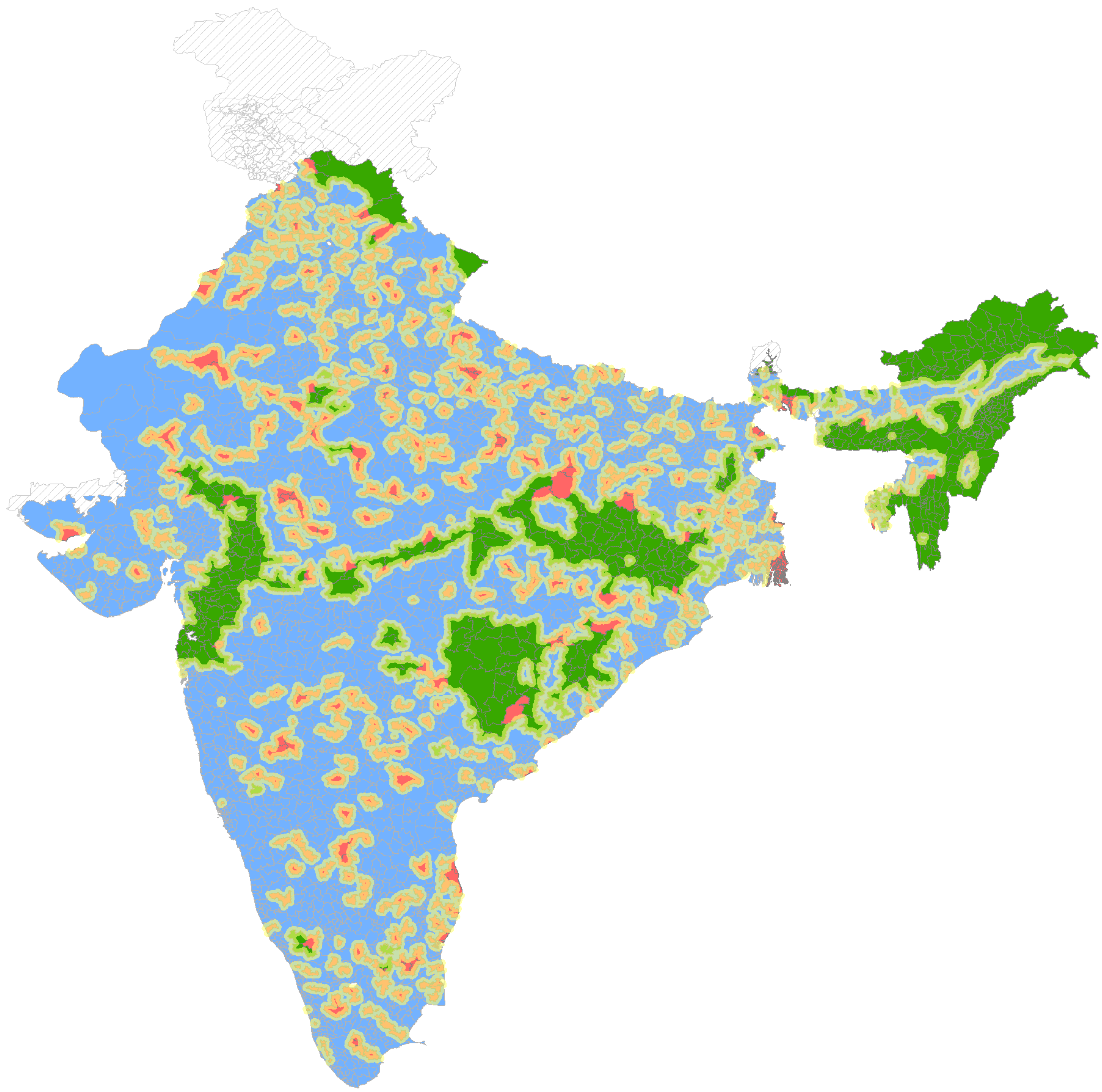
The sample for above regressions is all villages within 2 Kilometers of the reserved border averaged over the period 1992-2008. The dependent variable in columns (1)-(3) is average of the natural logarithm of light. In column (4)-(6) the dependent variable is the average rate of growth. In columns (7)-(9), the dependent variable is average of an indicator variable that is 1 if village emits any light and 0 otherwise. SC is a dummy variable that takes a value of 1 for constituencies that are reserved for the Scheduled Castes (SC) and 0 for unreserved (General) constituencies. All regressions include state fixed effects. Standard errors are clustered at the constituency level and given in brackets. The values with *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Figure 1: State Assembly Constituencies in India



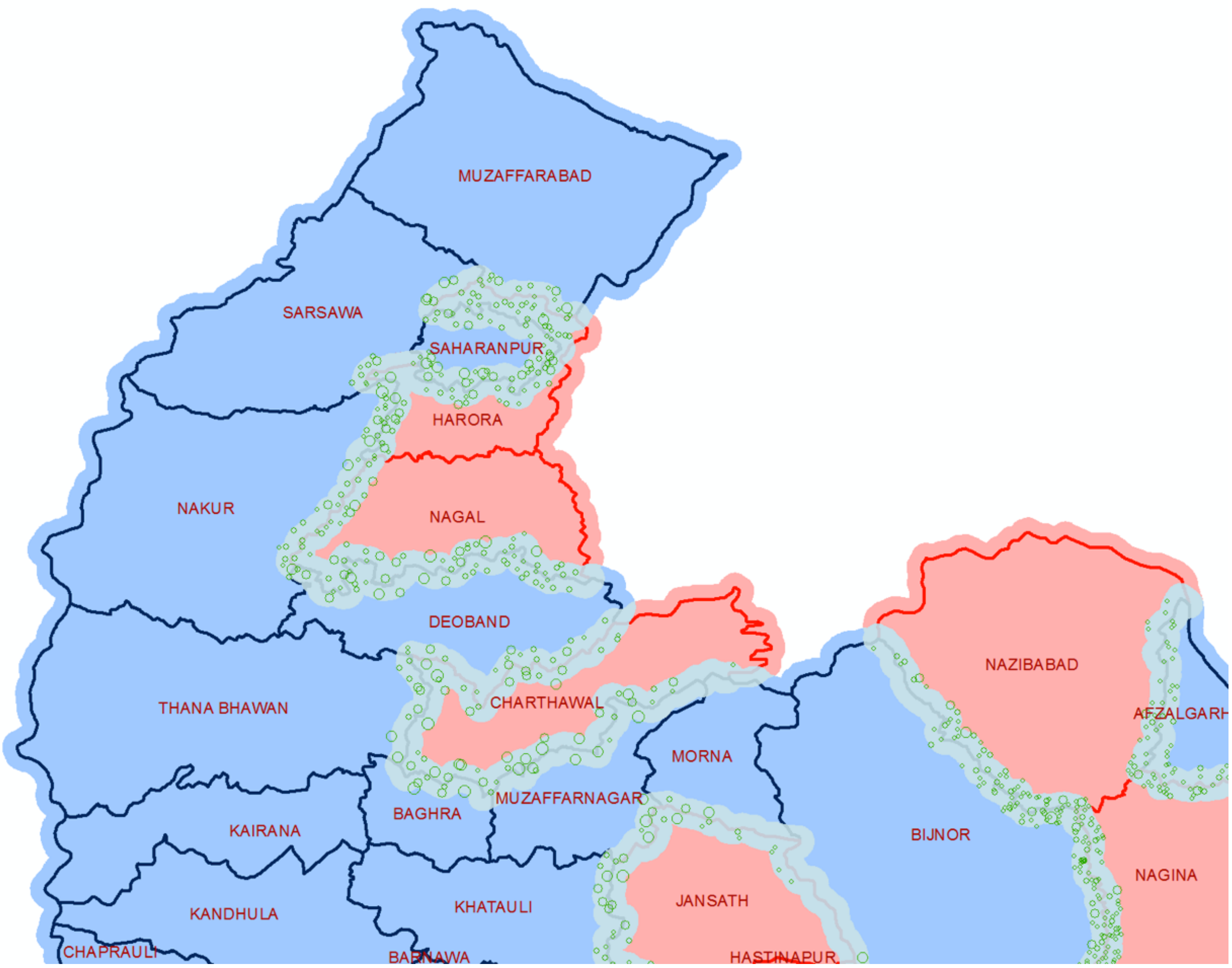
Blue = Unreserved seats
Red = Reserved (SC) seats
Green = Reserved (ST) seats
Source: MLInfomap. Map is of pre-2008 delimitation boundaries.

Figure 2: State Assembly Constituencies
With Buffer Zones Around Reserved Borders Highlighted



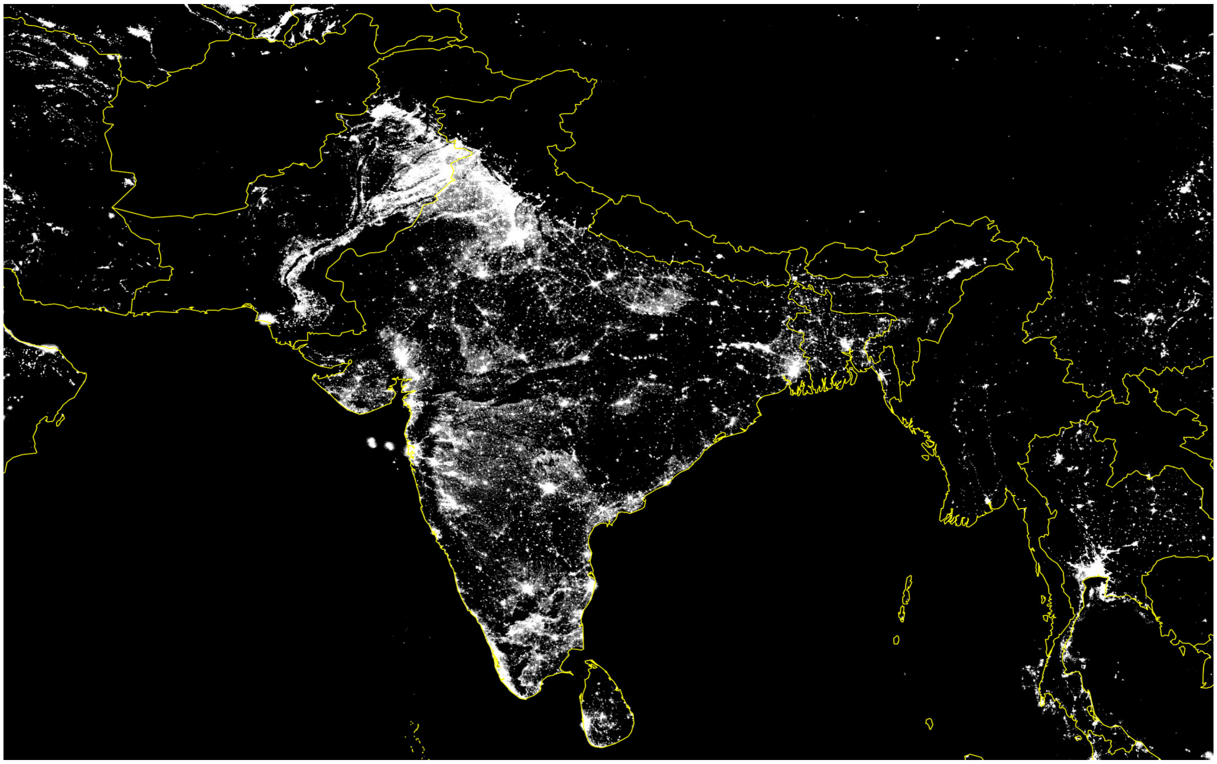
Source: MLInfomap. Map is of pre-2008 delimitation boundaries.

Figure 3: Villages within 2km of Boundary Between Reserved and Unreserved Constituencies

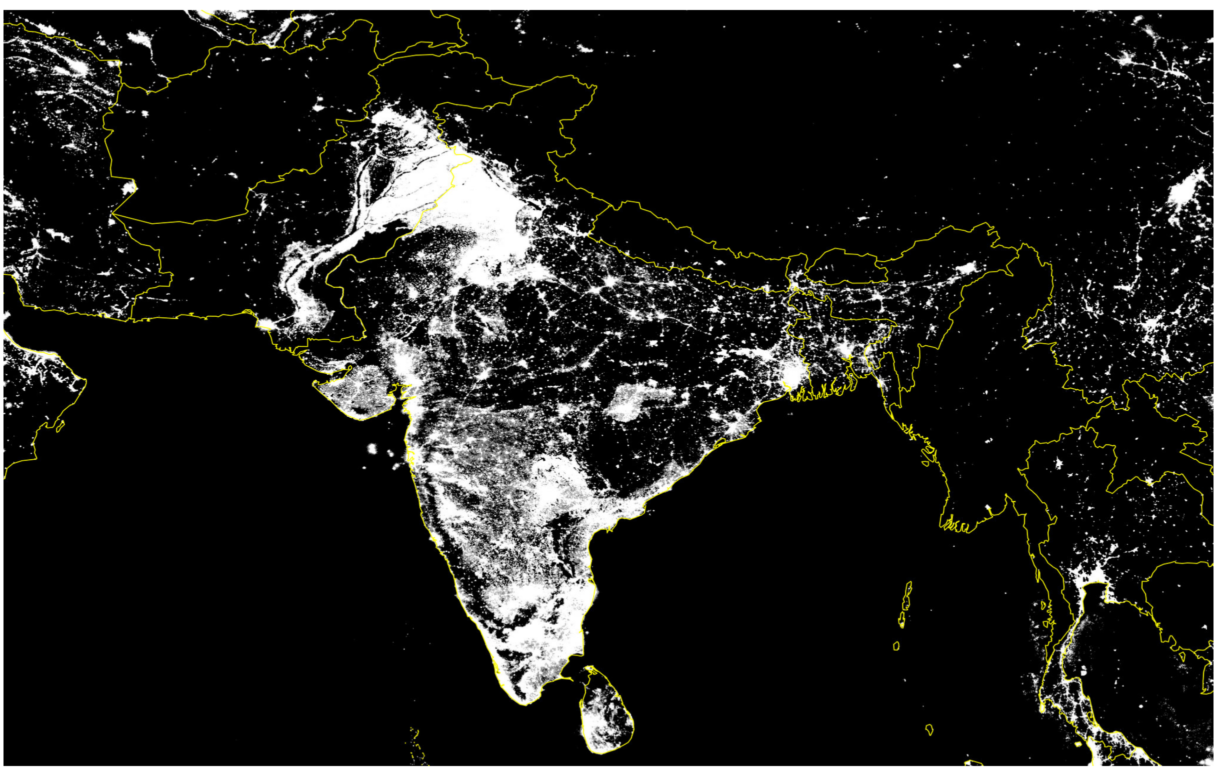


Villages denoted by green markers. Size of markers are scaled to village population.
Source: MLInfomap.

Figure 4: India at Night



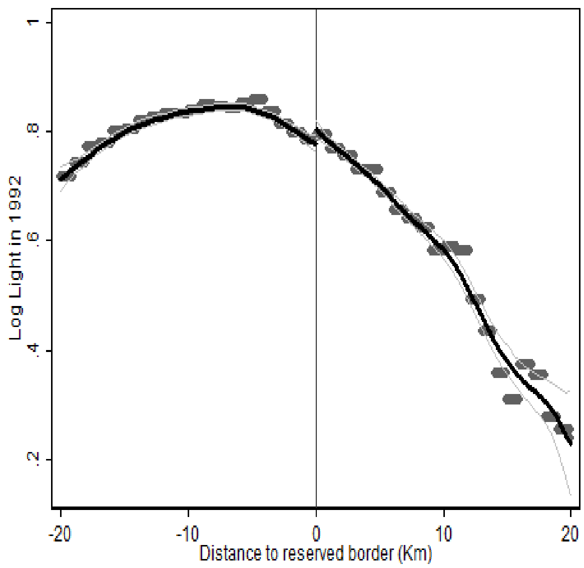
(a) 1992



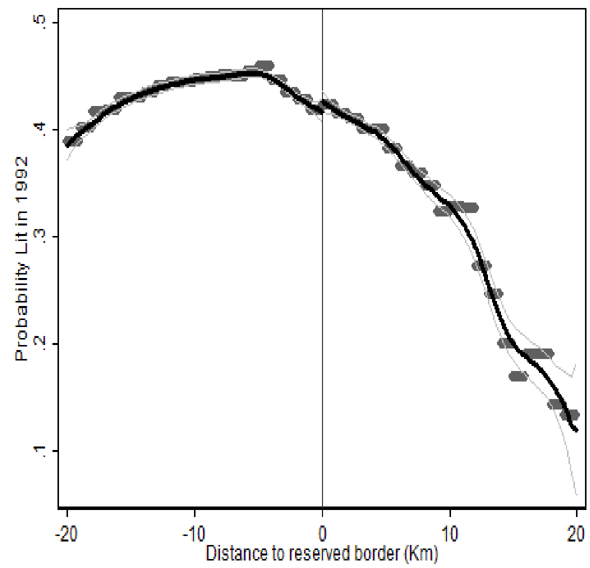
(b) 2009

Source: DMSP-OLS imagery from NOAA's National Geophysical Data Center.

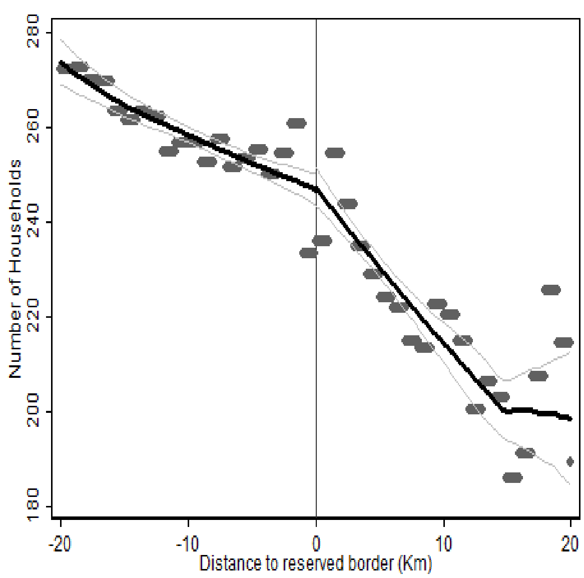
Figure 5: Balance Checks on Village Characteristics



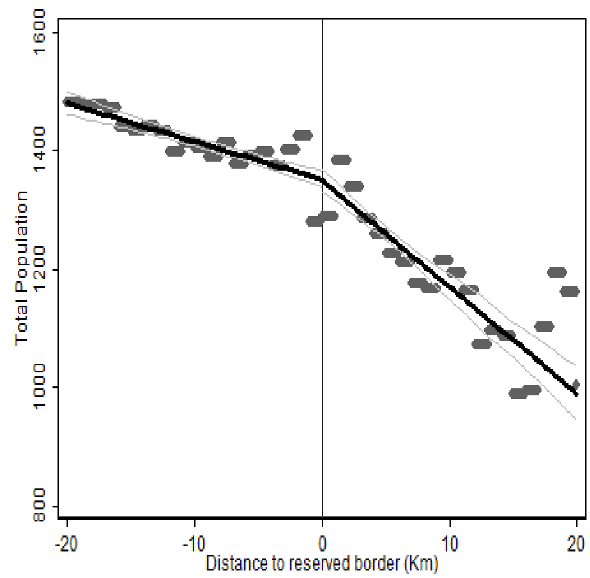
(a) Log Light in 1992



(b) Probability Lit in 1992



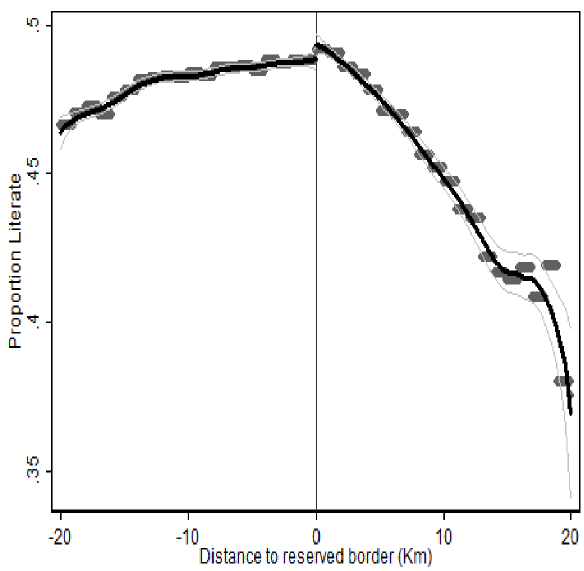
(c) Number of Households



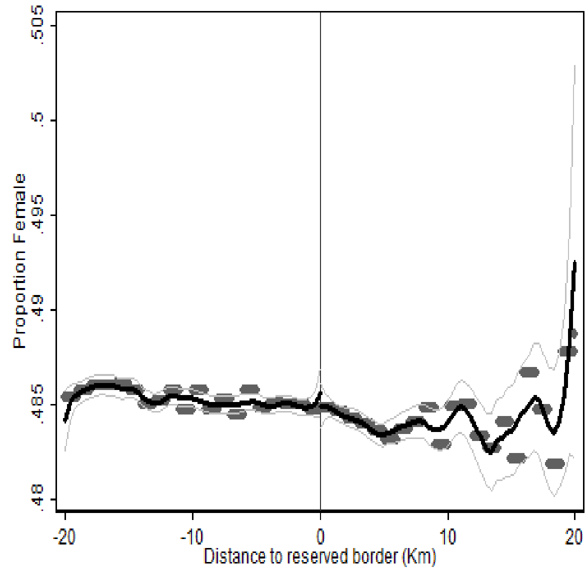
(d) Total Population

The running variable is the distance from the border between the nearest reserved constituency. Positive distances are villages in reserved (SC) constituencies. Negative distances are villages in unreserved (General) constituencies. The dots in the scatter plot depict the average of the dependent variable over each successive interval of 1 Kilometer. Lines are local linear regressions fit separately for reserved and unreserved villages using a triangular kernel and an optimal bandwidth calculator as suggested in (**?**). The confidence intervals are the 95% confidence intervals plotted using standard errors that are clustered at the constituency level.

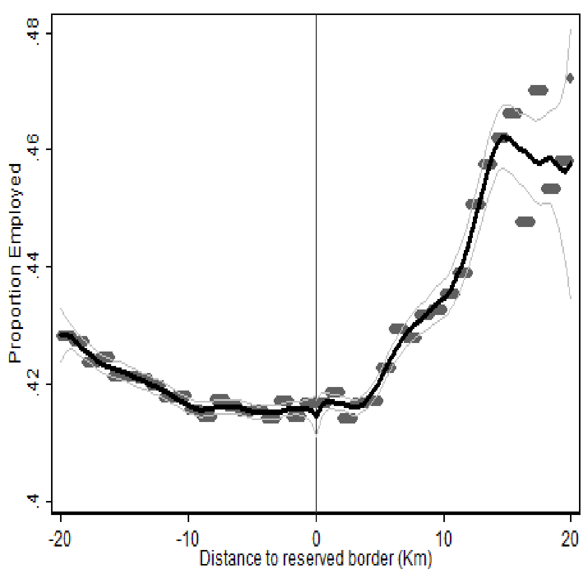
Figure 5: Balance Checks on Village Characteristics (Cont'd)



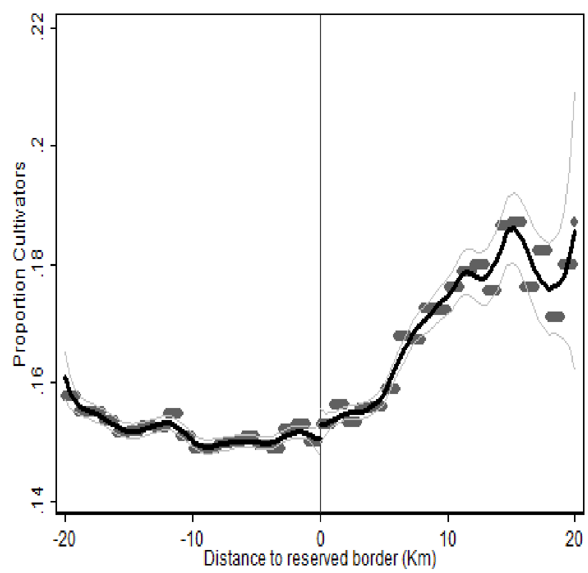
(a) Proportion Literate



(b) Proportion Female



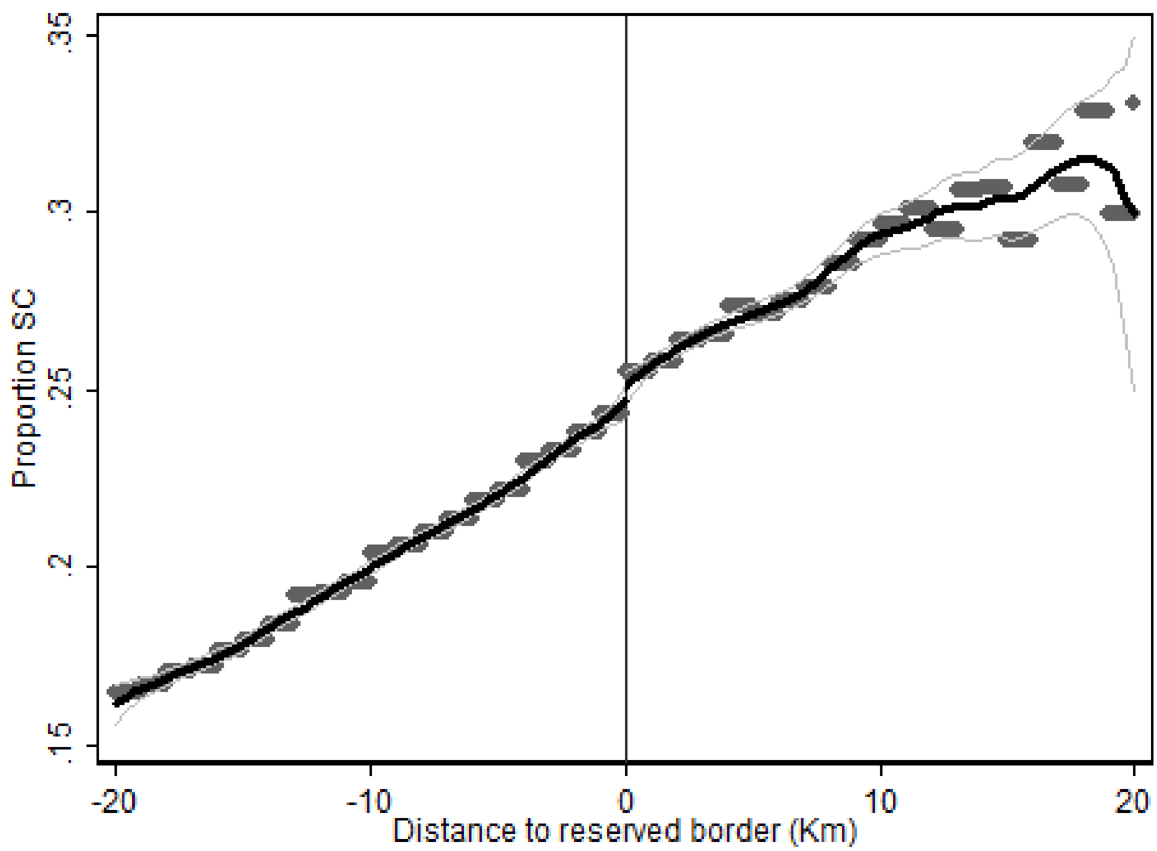
(c) Proportion Employed



(d) Proportion Cultivators

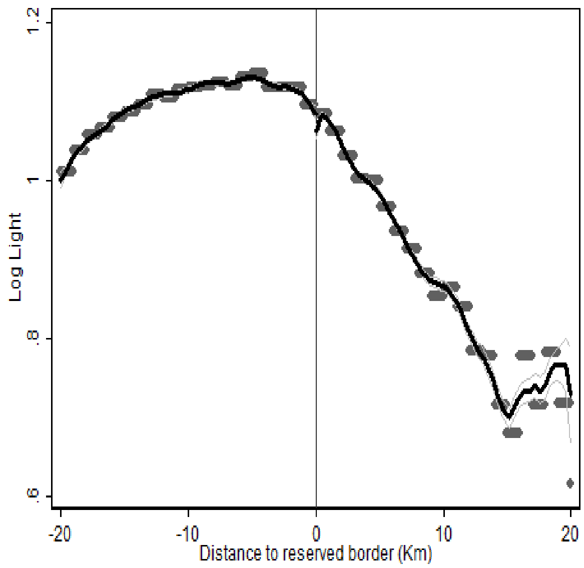
The running variable is the distance from the border between the nearest reserved constituency. Positive distances are villages in reserved (SC) constituencies. Negative distances are villages in unreserved (General) constituencies. The dots in the scatter plot depict the average of the dependent variable over each successive interval of 1 Kilometer. Lines are local linear regressions fit separately for reserved and unreserved villages using a triangular kernel and an optimal bandwidth calculator as suggested in (**?**). The confidence intervals are the 95% confidence intervals plotted using standard errors that are clustered at the constituency level.

Figure 6: Proportion SC Population

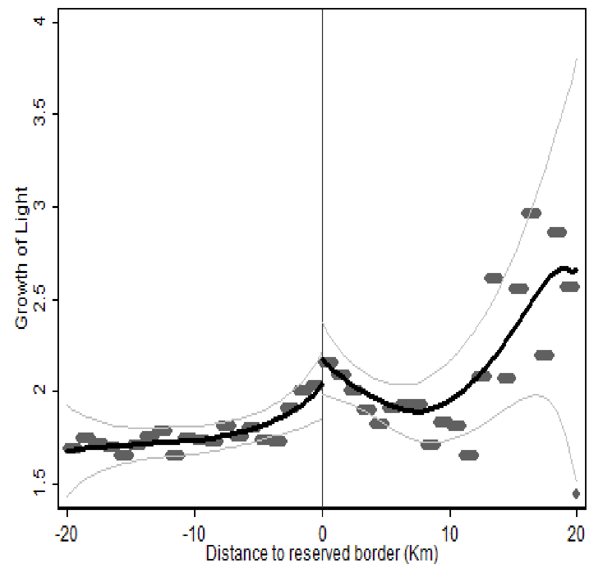


The running variable is the distance from the border between the nearest reserved constituency. Positive distances are villages in reserved (SC) constituencies. Negative distances are villages in unreserved (General) constituencies. The dots in the scatter plot depict the average of the dependent variable over each successive interval of 1 Kilometer. Lines are local linear regressions fit separately for reserved and unreserved villages using a triangular kernel and an optimal bandwidth calculator as suggested in (?). The confidence intervals are the 95% confidence intervals plotted using standard errors that are clustered at the constituency level.

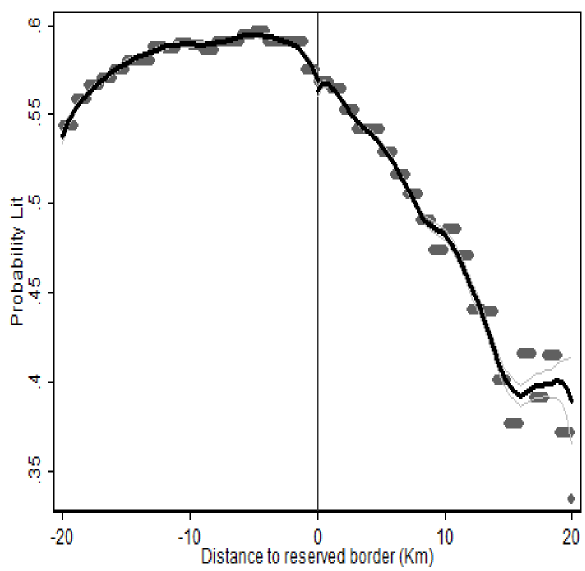
Figure 7: Effects of Reservation on Electricity Provision



(a) Log Light



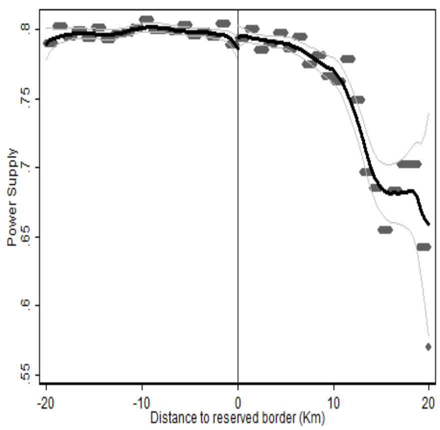
(b) Growth of Light



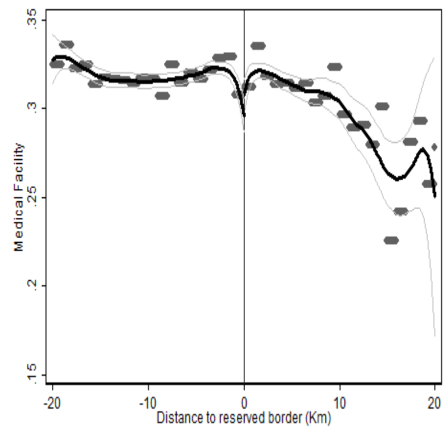
(c) Probability Lit

The running variable is the distance from the border between the nearest reserved constituency. Positive distances are villages in reserved (SC) constituencies. Negative distances are villages in unreserved (General) constituencies. The dots in the scatter plot depict the average of the dependent variable over each successive interval of 1 Kilometer. Lines are local linear regressions fit separately for reserved and unreserved villages using a triangular kernel and an optimal bandwidth calculator as suggested in (**?**). The confidence intervals are the 95% confidence intervals plotted using standard errors that are clustered at the constituency level.

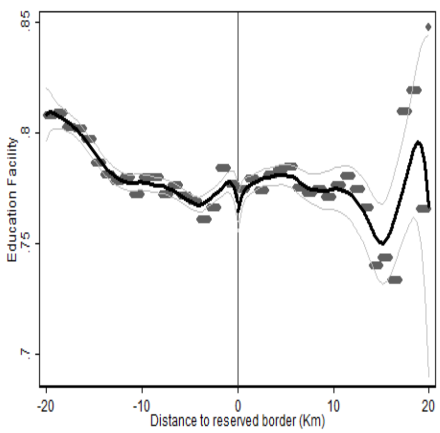
Figure 8: Effects of Reservation on Public Goods: Alternative Outcomes



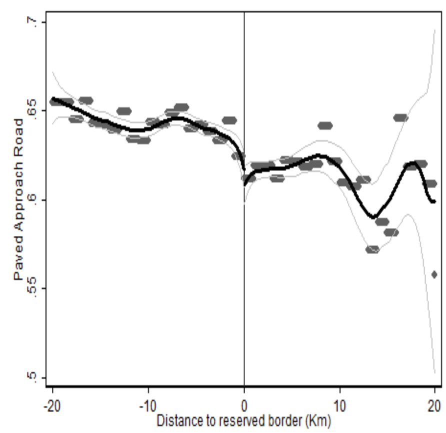
(a) Power Supply



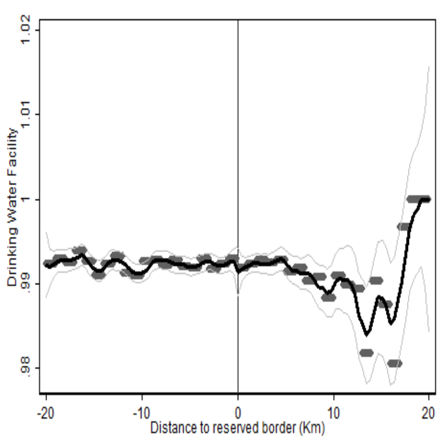
(b) Medical Facility



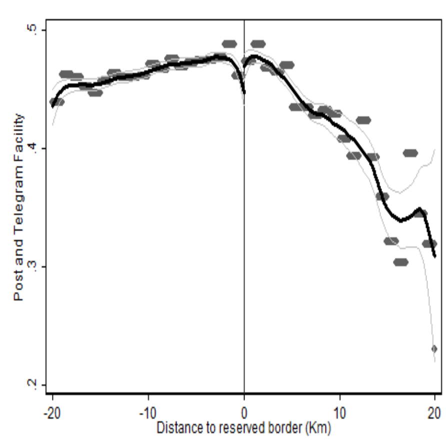
(c) Education facility



(d) Paved Approach Road



(e) Drinking Water Facility



(f) Post and Telegram Facility

The running variable is the distance from the border between the nearest reserved constituency. Positive distances are villages in reserved (SC) constituencies. Negative distances are villages in unreserved (General) constituencies. The dots in the scatter plot depict the average of the dependent variable over each successive interval of 1 Kilometer. Lines are local linear regressions fit separately for reserved and unreserved villages using a triangular kernel and an optimal bandwidth calculator as suggested in (**?**). The confidence intervals are the 95% confidence intervals plotted using standard errors that are clustered at the constituency level.