Quantifying Slum Electrification in India and Explaining Local Variation*

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Abstract

Unreliable electricity supply is a major obstacle to economic development in countries such as India. While electricity problems in the rural areas are widely recognized, scholars have yet to analyze the situation in urban slums. Drawing on 2004-2005 survey data from the India Human Development Survey, we document the electricity situation in slums. We find that while households located in slums are less likely to have access to the electricity grid than other urban households, the situation is significantly better than in rural areas. Based on simulations, we find that a median household in a slum has 70% chance of having electricity. This number decreases to 50% for a household in a rural area and increases to 80% for households in urban areas. As to daily hours of electricity available for connected households, urban slums also fall between other urban and rural areas. Finally, we show that these conditions vary considerably by state. Slums located in states with low corruption and leftist governments have better electricity access on average than those in states suffering from corruption or that are ruled by rightist parties.

Keywords: electrification; urbanization; slums; public goods; development

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1 Introduction

Reliable and affordable access to electricity is important to the development process of any country (Barnes, Van der Plas, and Floor, 1997; Ouedraogo, 2013; Sehjpal et al., 2014). Despite the importance of electrification, many emerging countries struggle to provide this basic good to their citizens. India, where 400 million people do not have access to electricity, is a classic example (Government of India, 2011). According to the literature, not all individuals are equally at risk of having to deal with poor electricity infrastructure (Balachandra, 2011; Chakrabarti and Chakrabarti, 2002; Kamalapur and Udaykumar, 2011). In urban areas, electricity is much more readily available and its supply more reliable than in rural areas.

The rural-urban distinction may provide an incomplete picture of the electricity problem in India, as it underestimates the complexity of the situation caused by *urban slums* (Shatkin, 2014). The Indian census defines slums as "residential areas where dwellings are unfit for human habitation by reasons of dilapidation, overcrowding, faulty arrangements and design of such buildings, narrowness or faulty arrangement of street, lack of ventilation, light, or sanitation facilities or any combination of these factors which are detrimental to the safety and health" (Government of India, 2011).[1] Based on 2011 census data, slums hosted about 68 million Indians (over 5% of the total Indian population and 17% of the urban population), and the number was growing.[2]

As urbanization continues unabated in India, the number of slum dwellers is expected to continue to increase. In the absence of significant policies which would improve the living conditions in these areas, people will continue to live at risk of poor health, violence, and poverty (Nakamura, 2014). In particular, improving access to energy and electricity is critical for development (Ghosh and Kanjilal, 2014; Parikh, 2012). This article sheds some light on the challenges faced by policymakers in the electrification of slums by contrasting their plight with the situation in rural and planned urban areas. To this end, we draw on survey data from the 2004-2005 *Indian Human Development Survey* (Desai et al., 2007). This large survey has data on the livelihoods and socio-economic conditions of more than 40,000 households from all states of India. The data clearly indicate whether or not the household lives in rural, urban, or slum areas. The

[1] In preparatory work for the 2011 census, a slum was defined in more detail as a "cluster of hutments with dilapidated and infirm structures having common or no toilet facilities, suffering from lack of basic amenities, inadequate arrangement for drainage and for disposal of solid wastes and garbage. These inadequacies make the living conditions in slums extremely suboptimal, unhygienic and result in usually higher incidence of air and water borne diseases for the dwellers," *Census of India 2011 - Circular No. 8* , `censusindia.gov.in/2011-Circulars/Circulars/Circular-08.pdf` (accessed June 1, 2013).

[2] "68 million Indians Living in Slums", *Times of India*, March 21, 2013.

survey questionnaire also contains detailed questions about electricity access and use. These data, collected a few years ago, are still highly relevant to understand Indian slums. Slums have continued to grow at a rapid pace. Based on data from the 2001 and 2011 censuses, we know that slums have increased by more than 10 million people at about 68 million individuals. Furthermore, while electrification has improved in urban settings (which include slums), going from 88 to 93%, this still leaves millions of people without a reliable access to electricity. Thus, the problem remains a major policy issue.

The goals of this article are threefold. First, we quantify the extent of slum electrification, both in terms of availability and reliability of supply, with explicit comparisons to rural and other urban areas. Second, we develop a statistical model of slum electrification to distinguish between the significance of the slum location and other factors, such as low household incomes. Finally, we shed light on the causes of variation in slum electrification by investigating the role of various political and institutional factors at the state level.

Our three goals are motivated by important gaps in the body of literature on electricity in developing countries. There is a large body of literature on energy access in rural areas, showing that the lack of modern energy services is a major obstacle to economic development (Cabraal, Barnes, and Agarwal, 2005; Bernard, 2010; Brass et al., 2012). While the stark reality is that developing countries are urbanizing faster than ever (Cohen, 2006; Montgomery, 2008), the literature on urban electrification problems in India and elsewhere is limited in scope. To the extent that urban electricity is considered at all, most studies (Barnes, Krutilla, and Hyde, 2005; Farsi, Filippini, and Pachauri, 2007; Pachauri and Jiang, 2008; DeFries and Pandey, 2010; Cheng and Urpelainen, 2014) do not distinguish clearly between slums and planned areas. One of our contributions is to make a clear distinction between these two areas, highlighting considerable variation between these two types of urban settlements and calling into question some previous findings concerning the high quality of electricity supply in urban areas. Our econometric methods are similar to those in existing studies, but our sample is much larger.

Available studies on slums in particular usually focus on limited geographic areas. Using data from a handful of Gujarati slums, Parikh, Chaturvedi, and George (2012) show that electricity is considered a basic priority service among slum dwellers. We shed light on the extent of electricity access in Indian slums across the country, also providing an explanation for variation across states. Baruah (2010) finds that non-governmental organizations in the city of Ahmedabad have allowed slum dwellers to gain access to improved electricity services through cooperation with electric utilities and municipalities. Schaengold (2006) documents the degree of electricity access in Mumbai slums and illuminates the causes of problems. These include the difficulty of payment collections, the lack of legal status of property, and poverty. He also considers the possibility of distributed, off-grid electrification for slums. Through survey research in Mumbai, Mimmi (2014) shows that affordability, lack of house ownership and legal title, the low quality of housing, and the complexity of community relations in slums are obstacles to regular electricity supply. Lipu, Jamal, and Miah (2013) report similar findings from Bangladesh, adding that the city of Dhaka lacks a specific energy policy for slums.

Our study provides a more detailed and representative analysis of slum electrification across all of India, precisely quantifying needs and benefiting electrification efforts by identifying priority areas. We go beyond the typical focus of slum studies, that is, metropolitan agglomerations with population in the millions. Using nationally representative data on India, ours is the first comprehensive study that considers slums in smaller cities as well. In doing so, we show that the problem of slum electrification reaches well beyond the typical metropolitan areas that others have studied, such as Mumbai. Finally, we describe and provide a political-economic explanation for variation in slum electrification across Indian states. Our study is the first to use nationally representative data to provide such an explanation across Indian states.

We begin by providing a summary of the electricity situation in slums. We then scrutinize the data in greater detail by estimating various econometric models. Third, we provide preliminary evidence for explaining the situation in urban slums. Finally, we discuss the implications of our findings.

2 Electrification and Power Supply in Indian Slums

We now characterize the electricity situation in India. Specifically, we compare and contrast the conditions faced by households located in slums with either planned urban or rural areas. While the situation in urban and rural areas has been studied elsewhere (Balachandra, 2011), little is known about slums. We show that urban slums fall somewhere between the two other types of areas. This is important, given that about 70 million Indians already live in urban slums, as discussed in the introduction, and that number is growing. Although the central government in New Delhi has emphasized the importance of turning slums into planned urban areas with proper infrastructure and amenities, in practice the current policies and schemes suffer from several weaknesses and are making at best slow progress (Kundu, 2013).

2.1 Data on Electricity in Rural, Urban, and Slum Areas

We draw on data from the *India Human Development Survey* (IHDS), which was administered to over 40,000 households across India (Desai et al., 2007). The survey was conducted in 2004-2005 and covers a broad range of questions. Importantly, the survey is representative of the broader Indian population once the appropriate weighting scheme is used. Since the IHDS combines samples conducted in rural and in urban areas, IHDS provides weights on each observation (respondent) to make the combined survey representative of the population.

The data have several advantages over typical alternatives. Although the 2011 Census of India would provide an overview of basic electricity access, the raw household data are not available for researchers. Moreover, the census data do not provide details of electricity payments or daily hours of access. In this regard, the IHDS data are much more precise. The other standard alternative is the National Sample Survey (NSS) data. Conducted every five years, this major survey collects detailed data on household expenditures. However, the NSS data do not distinguish between slums and planned urban areas. Moreover, there is no data on hours of electricity access. Again, the details of the IHDS dataset make it uniquely suitable for our analysis.

We focus on two variables of interest. First, we examine if households have electricity. The question given is "Does this house have electricity?" and the answer is coded 1 if the household has electricity and 0 if not. Overall, we find that 72% of all households in the sample have electricity, though this number varies considerably by location, as we document below.

Second, beyond having electricity, the *reliability* of electricity is particularly important. While many households are officially deemed to be connected to the electricity grid, India regularly suffers from massive blackouts. Hence, we also examine the number of hours per day during which electricity is available. The question is "How many hours per day do you generally have power?" and measured in numbers of hours. The sample average is almost 16 hours, with a standard deviation of 7.

While we focus on electricity availability and reliability, we do not distinguish between legal and illegal access to the grid. Electricity theft is a major issue in India: its cost to utilities has been estimated to $4.5b per year (Depuru, Wang, and Devabhaktuni, 2011). While we do not have data on the amount of electricity theft from Indian slums, the survey has information on methods of electricity payment. Around 56% report paying their electricity bill to the State Electricity Board (SEB), and respondents who pay their electricity indicate spending up to 9,000 rupees per month (about $145) with a mean of 191 rupees (about $3). Urban residents are most likely to receive a bill from the SEB (80%) followed by slum dwellers (72%) and rural villagers (48%). About 12% of the total respondents say that they do not pay any bill and the pattern is similar across the three groups. Around 15% of the rural respondents did not pay for their electricity compared to 10% for slum dwellers and about 5% for urban residents.

Are there systematic variations in access to electricity and the number of hours of reliable electricity depending on a household's location? IHDS records whether each household is located in an urban area, an urban slum, or in a rural area. In the sample, 72% of the respondents lived in rural places, 26% in urban areas, and only 1.7% in urban slums. The latter clearly undervalues the number of people living in slums, since we know from census data that the true number is above 5%. To reduce concerns about the under-representation of people living in slums, we proceeded as follows. We created an alternative set of weights where we we increased the importance of slum inhabitants until their weighted share of the sample was above 5%. The results are extremely similar to our main findings, and are reported in Table A6.

In Figure 1, we start by graphing the electrification rate (top panel) and the number of hours of electricity (bottom panel) in each of the three groups. We find that slums have similar electrification rates as urban areas, with both being above 90%. Rural areas, on the other hand, lag significantly behind, with an electrification rate below 70%. The rural electrification problem is well known. Importantly, as we indicate above, having access to the electrical grid is not the same as having *reliable* electricity. When considering the number of hours a household claims to have power, we find that slums seem much more similar to rural areas, with almost 14 and 15 hours of electricity on average per day, respectively. Urban areas on the other hand benefit on average from almost 19 hours of reliable electricity per day.

[Figure 1 about here.]

We next go beyond these sample averages and look at the broader distribution of hours of electricity per day. In Figure 2, we illustrate for each group the distribution of the number of hours a household has reliable power. Again, slums appear closer to rural areas than to urban centers. The distribution of the latter is clearly left-skewed; in contrast, there is greater variation *among* slums. Slums that surround one of the major metropolitan centers such as Delhi or Mumbai fare much better than others. We find that these slums have on average 14 hours of electricity, whereas those bordering the main metropolitan centers have on average almost 20 hours of daily electricity.

[Figure 2 about here.]

So far, the overall picture suggests that urban areas are privileged while rural areas are at a disadvantage. While this finding is unsurprising, our emphasis is on slums. Here, we find that they typically range between rural and urban areas. To verify the robustness of our findings, we next conduct various econometric analyses to identify whether this finding holds when controlling for various possible confounding factors.

2.2 Econometric Estimation

We conduct various econometric analyses to ensure that our findings hold when maintaining various socio-economic parameters constant. The econometric techniques allow us to control for effects of variables that are correlated with urban slum status, such as household income and education, and could also influence electrification and power supply.

In particular, four elements are important. First, access to electricity is a function of a household's wealth (Bhattacharyya, 2006; Filippini and Pachauri, 2004). While there are various reasons why richer households have better electricity access, the most relevant one for our study clearly is that richer households are more likely to live in urban neighborhoods that are already connected to an electricity grid. In our data, there is a strong and positive correlation between household wealth and being an urban dweller ($r = +0.414$, $p = 0.000$). Ignoring this spatial relationship by not controlling for household wealth in our statistical models would bias the estimation results. Thus, we include information on household wealth in our more comprehensive model specifications.

Unfortunately, our data does not provide an immediate measure of wealth. To get such a measure, we follow the literature and construct an index for a household's wealth. The idea is straightforward: we can use knowledge about the assets that a household possesses to estimate how wealthy it is. The key then is to combine these possessions in a single variable that will indicate whether a household is wealthy or not. Factor analysis is a popular and widely-used method to create such an index and has been often used in the case of India (Filmer and Pritchett, 2001).

Concretely, we examine whether a household possesses the following items: a bike, a mixer/grinder, a sewing machine, a motor cycle, a watch, a cell phone, a chair or a table, a cot, and a pressure cooker. These items do not necessarily require electricity at home to function.[3] This index thus does not induce endogeneity. Then, we perform a factor analysis to derive an index of wealth. We find that the first dimension of the factor analysis picks up most of the variance; it is largely determined by the possession of a mixer/grinder, and motorcycle, a cell phone, and a pressure cooker.

In Figure 3, we plot the distribution of income for each of the three locations. We report the Kernel density estimates (notice that the Kernel estimates can go above 1; it is the area under the curve that integrates to 1). Unsurprisingly, we find that respondents in urban areas tend to have a higher value, while rural households tend to be poorer, with slum inhabitants in between. Since this distribution is plausible, it increases our confidence in the index. Nonetheless, we report in the appendix the estimates when controlling for logged income (Table A2). We do not report these here because self-reported income might be unreliable.

[Figure 3 about here.]

Second, we control for education, measured in years. As variation in education levels may lead to changes in the need for electricity, we control for education in some of our econometric models. Work by Farsi, Filippini, and Pachauri (2007) on fuel choice of urban households in India, for instance, finds a positive effect of education, even independent of income. In our case, more educated households may have more need for electric assets, and this could increase their willingness to pay for a connection, making them more attractive customers, both for private and public electricity generators, and thus making electricity access more likely. Including years of education as a control, therefore, seems appropriate. In our sample, the average number of years of education is between 7 and 8 years, with a standard deviation of 5 years.

Third, we control for household size. The more individuals live in a household, holding everything constant, the greater the need for electricity. Also, since electricity within a household is close to a public good, it means that larger households may also be more likely to be able to afford some connection to the electricity grid. On the other hand, larger households may also be more common in poorer areas. Importantly, Filippini and Pachauri (2004), for example, find a statistically significant, albeit negative, effect of household size on electricity consumption. Even though the exact relationship may need further exploration,

[3] In the appendix, we report the results when using an alternative wealth index that excludes cell phones and mixer/grinders (Table A5).

the possibility of household size being correlated with our main variables of interest leads us to control for household size to avoid bias in our estimation results.

Next, we control for agricultural activity. The agricultural sector in India is large, and over 40% of the respondents in our sample report owning or cultivating land. Agricultural production not only generates high demand for commercial use of electricity, but farmers are also often granted free or highly subsidized electricity access by local politicians, mostly as rewards for reelection (Joseph, 2010; Min and Golden, 2014). This variable thus enables us to capture part of the divide between rural and urban areas and hence warrants inclusion in our econometric specifications.

Finally, since there is considerable variation across states in the quality of electricity supply (Santhakumar, 2008), we include state fixed effects. These account for systematic differences between each Indian state that uniformly affect people living there. All variables are summarized in Table 1.

[Table 1 about here.]

Using these control variables, we estimate two identical model specifications, which only differ in the used estimation technique due to different dependent variables. Since our data set provides us with information on whether a household has electricity access or not and how many hours per day a household has electricity, we leverage both variables for our empirical analysis. As our first dependent variable, that is, electricity access yes or no, is clearly a binary variable, we estimate a logistic regressions to account for the non-normal distribution of our electrification variable. With this logit transformation Λ and i indexing households, our first estimation equation is given as

$$\text{Electrification}_i = \Lambda\left(\alpha + \beta_1 \text{Rural}_i + \beta_2 \text{Urban}_i + \gamma' \mathbf{X}_i + \tau_j + \varepsilon_i\right),$$

where β_1 and β_2 are the main coefficients of interest, $\mathbf{X}$ is a vector of the above discussed control variables, α denotes the intercept, τ_j denotes state fixed effects for states j, and ε represents the random error term. We report robust standard errors clustered by state and weight observations using the IHDS weighting scheme to ensure representativeness of our sample. As we treat slums as our reference category and expect it to lie in between electrification rates of urban and rural areas, respectively, we expect the coefficient β_1 of the rural dummy to be negative, while β_2 for the urban dummy should be positive.

For our second dependent variable, i.e., hours of electricity per day, which is a continuous measure of the reliability and quality of the electricity grid, we estimate a standard OLS linear regression model. The model specification is identical to the one for the logit model, and the estimation equation looks as follows

$$\text{Hours of Electricity}_i = \delta + \lambda_1 \text{Rural}_i + \lambda_2 \text{Urban}_i + \psi' \mathbf{X}_i + \theta_j + \epsilon_i,$$

where again λ_1 and λ_2 are the main coefficients of interest, which capture the effect of living in rural or urban areas on hours of electricity, $\mathbf{X}$ is a vector of the same four control variables, and δ, τ_j, and ε denote the intercept, state fixed effects, and the error term, as before. Similarly, we expect λ_1 to be negative and λ_2 to be positive, for the same reasons as discussed above. In essence, the parameters β_1, β_2 and λ_1, λ_2 tell us how rural and urban areas compare to slums, both in terms of electrification status (logit model) and hours of electricity provision (OLS model).

2.3 Results

We report our estimation results estimates in Table 2 below. The first four columns show the results for our logistic regression model, while columns (5)-(8) provide results from OLS estimations. For each class of models, the specifications become gradually more comprehensive. First, we only include the two dummy variables on living in rural and urban areas, to then add state fixed effects, the wealth index, and finally all other socio-economic covariates that we discuss above. To reiterate, the first four models tell us how rural and urban areas compare to slums (the omitted category) in terms of binary electricity access, whereas the last four models capture the effect of geography on hours of electricity, as continuous measure of grid reliability.

[Table 2 about here.]

First, we focus on the results from the logistic regressions, which lend additional support to our descriptive findings. The coefficients for the rural and urban dummies are correctly signed across all models and statistical significance is typically strong, albeit a bit weaker for the effect of living in urban areas. These results suggest that, relative to electrification in slums, households in rural areas are less likely to be electrified, whereas urban dwellers are more likely to obtain the benefits from electrification. This effect is robust to state fixed effects and the inclusion of our control variables.

To further scrutinize what our estimation results mean substantively, we simulate the likelihood of having electricity for a representative household (King, Tomz, and Wittenberg, 2000). For this, we use the estimates from Model (4) to predict the chance for a household to have access to the grid and set all other variables to the sample median, while arbitrarily locating our household in Uttar Pradesh, the largest Indian state, with about 200 million inhabitants. Since Model (4) is the most comprehensive one, it is least likely to suffer from omitted variable bias and thus makes for a natural candidate to be used for our simulations. This is the more so as likelihood ratio tests indicate that this model is statistically significantly different from the other three specifications and has the highest predictive power of all our models, with 85% correct predictions. In light of our expectation that slums hold a middle position in terms of electrification, the coefficients for the rural and urban dummies are among the smallest in absolute value, posing the most difficult test for our hypothesis to pass. This stacks the deck against artificially inflating the size of the predicted effects.

[Figure 4 about here.]

Figure 4 illustrates the simulation results visually and carries home one key insight: the likelihood for having electricity access varies greatly with location. A median household in rural Uttar Pradesh has less than a 50% chance of being electrified, while this likelihood increases to about 80% for urban households. If the household were to be located in a slum, however, the model prediction for having electricity access lies in the range of 70%. Because of the large sample size, these effects can be estimated with sufficiently precise standard errors, which do not overlap and, thus, make us confident that there is a statistically significant and substantively important difference between a household's location and electricity access.[4]

We now shift our focus to our second dependent variable and assess the effect of location on hours of electricity. The estimated coefficients are again correctly signed for both rural and urban areas, suggesting that rural households have between 1.25 and 2.04 hours less electricity per day than households in slums. The urban advantage vis-à-vis slum households is even more pronounced in absolute terms, ranging from about 1.86 to 3.69 hours more electricity on an average day. These effects are large, but are never statistically significant, which is why we caution against a too literal interpretation. Notwithstanding this, these sizeable predicted differences for rural, urban, and slum areas are interesting, even if only from a descriptive

[4]The effects are similar when estimating a linear probability model instead of a logit model, while using the same model specifications as in Table 2. We find that the difference between rural areas and slums ranges from 14 to 30% points.

perspective.

Finally, in terms of control variables, our models show that wealthier and better educated household are more likely to have electricity access, to begin with, and can also expect more hours of electricity per day. Household size does not seem to be statistically significantly correlated with any of the two dependent variables, and the coefficient is small in size. Interestingly, households with agricultural production may be more probable to be granted access to electricity – even though this result is not statistically significant –, yet obtain about 50 minutes less electricity a day. This is anecdotal evidence, which, however, bodes well with the narrative in Indian politics that local politicians have incentives to provide farmers with electricity access, but the quality and reliability of these grid connections are usually very poor (Narendranath, Shankari, and Reddy, 2005).

3 Variation in Slum Electrification across Indian States

Having established the general pattern of slum electrification in India, we now turn to explaining variation within the country. In particular, we examine variation across states. Since electricity is a concurrent subject in the Constitution of India, the state is a natural unit of analysis for this. After describing the variation, we propose and test different explanations for it. Overall, we find that the availability and reliability of electricity for slums varies considerably across states. Further, we provide evidence that there are political reasons for this variation. While any analysis of this kind is necessarily preliminary due to the small sample size (we can only compare a small number of states), the results are of sufficient interest to report to inform future research.

3.1 Describing the Variation

In Figure 5, we report the electrification rate (top panel) and the average hours of daily electricity (bottom panel) in slums across Indian states. States that are not reported here did not have respondents living in slums in the sample; this leaves us with a total of eleven states.

[Figure 5 about here.]

We find that diverse states such as Karnataka or Uttar Pradesh have a high electrification rate. This is surprising, given that electrification rates overall are much better in the wealthy southern states, such as Karnataka, than in Uttar Pradesh. People living in slums in Assam, on the other hand, must deal with poorer conditions with an electrification rate of only 60%. These numbers hide important differences in the quality of electricity. Slum inhabitants in Uttar Pradesh, for instance, only have about 9 hours of electricity per day. Thus, while they officially have electricity, they cannot rely on it. The quality of infrastructures in states such as Orissa, on the other hand, is high. Electrification rates are above 80%, and those lucky to have electricity can rely on it, since they have almost uninterrupted connection to the grid.

3.2 Possible Explanations

Can the availability and quality of electricity for slums be systematically explained? Since not all slums are equal, we explore possible reasons that may explain why this is so. Here, we explore three related hypotheses, all focused on politics and governance. We emphasize these factors because politics and governance are directly relevant to policy formulation and, therefore, of importance for today's pressing challenges in India. Another reason for this focus is that factors such as state income levels do not seem to have great explanatory power. For example, relatively poor Uttar Pradesh has a higher slum electrification rate than the richer Gujarat.

First, corruption may play a role. Corruption reduces the quality of public services. It has been related to poor energy and environmental governance (Fredriksson, Vollebergh, and Dijkgraaf, 2004; Cole, 2007; Aklin et al., 2014). Instead of being used to design and enforce good regulations, resources are diverted to the personal profit for bureaucrats. There have then little incentives to remedy these problems (Hu, Huang, and Chu, 2004). The effect of corruption may be particularly large on the reliability of the electricity grid. Households may nominally be connected to the grid, but the latter may regularly break down. In urban areas, connecting slum households to the grid is generally possible, but the goal is achieved only if government officials do their job and put resources to good use. Since almost all Indian states have public utilities and distribution companies, corruption is a major threat to the ability of a state government to improve slum electrification. In a study of 80 Latin American distribution companies, Dal Bó and Rossi (2007) find that, in corrupt countries, electricity distribution is much less efficient than in countries with low levels of corruption.

Second, we investigate whether government ideology plays a role. State governments ruled by center-left parties may have an incentive to target slum inhabitants. Since people living in slums are poorer, they are a source of votes for centrist parties, such as Congress or the Telugu Desam Party in Andhra Pradesh

(Chhibber, 2014), or local parties like Rashtriya Janata Dal in Bihar. In addition, the communist parties in India generally campaign on providing benefits to marginalized and poor habitants, along with reform policies that promote the same goal (Kohli, 1987; Franke and Chasin, 1994). In contrast, right-wing parties may prefer to eschew slum electrification because wealthier urban households, who prefer rightist to leftist leaders, do not reward the government for improved slum electrification. In the extreme, right-wing voters may even prefer to evict slum dwellers, thus worsening the slum electrification situation.

Finally, local governments may also benefit from support from the central government. As stated above, electricity in India is a concurrent subject that is governed by both the central and state governments. Consequently, central-state cooperation is useful for progress in electrification. Such cooperation is more likely when the national and local ruling parties are aligned, as they would then share the same ideology and electoral incentives (Sinha, 2004; Rao and Singh, 2005). As long as people will credit the central government for improved governance, the New Delhi rulers will indirectly benefit from improvements at the local level. The central government thus has an incentive to favor states run by the same party. In contrast, opponents can be punished by refusing to allocate public money for local public goods, such as slum electrification. We thus hypothesize that electrification should be higher and better in states that have elected the same party at the state and the national level.

3.3 Evidence

We begin by testing the effect of corruption on electricity in slums. To do so, we used data on state corruption from Transparency International (2005). Transparency International and its partner, the Centre for Media Studies, developed an index of corruption at the state level. Their data captures "petty corruption experienced by common man in availing public services" (Transparency International, 2005: 5). The index is based on both experienced and perceived corruption. Issue areas include dealing with the police and school officials, or when paying electricity bills. Twenty states were assessed and given a score. The least corrupt is Kerala (with a score of 240), the most corrupt one is Bihar (score of 695).

Taking weighted averages by state, we plot the average electrification rate and the average hours of electricity per day in slums based on their corruption levels. The result is shown in Figure 6.

[Figure 6 about here.]

The left panel shows electrification rates in slums based on each state's corruption score. Corruption appears to decrease electrification rates by up to 10%. States with low levels of corruption benefit on average from an electrification rate above 90%. On the other hand, states that suffer from high levels of corruption have an electrification rate that is about 80%. The results are similar when we consider the number of hours of electricity households have on average (right panel). Here, we find that people living in states with low corruption have about 18 hours of electricity per day. In contrast, those living in states with high degrees of corruption only have about 16 hours of electricity per day on average. The effect would be even stronger if we ignored Andhra Pradesh who is clearly an outlier.

Next, we explore the effect of ideology. We proceeded as follows. First, we collected data on the ideology of the ruling party in each state 1990-2004 from the Election Commission of India (we limit the sample to 2004 because this is when the main survey was conducted). Right-wing governments were given a score of 1, left-wing governments obtained a 5. We then averaged this score over the full period. States that had a score above the median were denoted as 'leftist,' and those with a score below are 'rightist.' The results are reported in Figure 7.

[Figure 7 about here.]

Evidence suggests that slums benefit from electing leftist governments. Not only is the electrification rate higher (98% versus 91%), but the reliability of electricity is substantially higher in states that have tilted to the left. Slums had on average almost 20 hours of daily electricity compared to less than 14 in states that elected rightist governments. Based on a t-test, the gap—about six hours—is statistically significant. This suggests that slums are targeted by officials, presumably as a source of votes.

Finally, we considered vertical dynamics between the central ruling elites and state governments. Our expectation is that the more overlap there is between the central and the state government, the more resources are made available to the latter, and thus the better the electricity grid. To assess the strength of this claim, we first computed the number of years of overlap between central and state governments between 1990 and 2004. We then split the sample in two. Slum inhabitants living in states that have spend more than the median amount of years with the same state and national governments were put in the 'high overlap' group. The rest were grouped in the 'low overlap' subsample.

[Figure 8 about here.]

We find conflicting evidence for this hypothesis. While electrification rates were about 6% higher in 'high overlap' states, the average number of hours of electricity per day declined from about 18 hours to 15 hours, with a decrease of three hours. We offer two conjectures to explain this paradox. First, if ambitious state authorities decide to expand the grid to slums, where maintenance is difficult and electricity theft occurs, the reliability of electricity supply could decrease. Slum areas are characterized by a variety of social, economic, and infrastructural constraints (Field, 2005; Schaengold, 2006; Nakamura, 2014). While slums are often conveniently located around city centers and business districts, electrification is challenging due to the low quality of housing and the lack of legally defined property rights. In addition, some slum areas suffer from safety issues that complicate maintenance. This could decrease the average number of hours during which households have electricity. Thus, the decrease in reliability would be a consequence of the government's attempt to reach the less privileged. Second, the conflicting evidence may be due to the incentives faced by local authorities. To obtain funds from the central government, they have to show that they have efficiently used these resources. It is easier to report a higher electrification rate than to provide evidence of an increase in the quality of the grid. Thus, electrification is a better signal of good implementation than increasing the hours of electricity.

4 Conclusion

This article has evaluated the electrification situation in the urban slums of India. We have found that the situation in urban slums falls somewhere between rural and fully developed urban areas. Although the descriptive statistics do not suggest a large difference between slums and other urban areas, the econometric analysis reveals a statistically significant effect. The descriptive difference between supply of electricity in slums and other parts of towns and cities is almost four hours, but the econometric model suggests a difference of less than two hours when we control for other influences, and the confidence intervals around this estimate are wide.

The findings show that a gap remains in Indian cities between the electrification of slum and other areas. While the problem is less severe than in the countryside, the cost of improved electricity supply could also be much lower due to higher population densities and geographic proximity to power plants. A policy intervention would have to consider the low quality of housing, which may present technical difficulties, and deal with the problem of poorly defined property rights. In addition, the safety of the technicians and payment collectors would have to be guaranteed. If successful, investment in slum electricity supply could lead to other improvements. Indeed, previous research has found that providing electricity to slum dwellers changes their aspirations toward less basic needs, such as education and employment (Parikh, Chaturvedi, and George, 2012). In this regard, improved power supply to urban slums could be an important way to empower and transform slum areas so that their residents can benefit from the economic opportunities that cities offer.

Achieving this goal will depend on benign political conditions. We have shown that corruption, ideology, and strategic dynamics between the central and state governments have an effect on slum electrification. Slums have benefited from leftist governments and less corrupt institutions. The effect of alignment between local and national authorities is less straightforward. In any case, the fate of slums depends on obtaining political support and improving the quality of institutions. Finding ways to empower people living in slums in adverse situations must be a key objective for stakeholders.

While we have contributed a comprehensive overview of slum electrification in India and provided explanations for variation across states, we recognize that much more research is needed. Our study has not investigated the aspirations, attitudes, and willingness to pay of slum dwellers. A representative survey of slum dwellers could address this gap. We also did not evaluate the effectiveness of possible policy interventions, such as participatory electrification, and new technical designs to deal with theft. Concrete field studies and randomized controlled trials could address this problem. There is also a clear need for large and comprehensive surveys of slum electrification in other countries. For example, India's situation could be compared to urban slums in other South Asian, African, and Latin American countries. Finally, our dataset provides an excellent point of departure for a longitudinal analysis. The IHDS team is working on another round of surveys, with the goal of interviewing the very households from the 2004-2005 again. Our data analysis gives a baseline for future studies of changes in urban, slum, and rural electrification over time across India.

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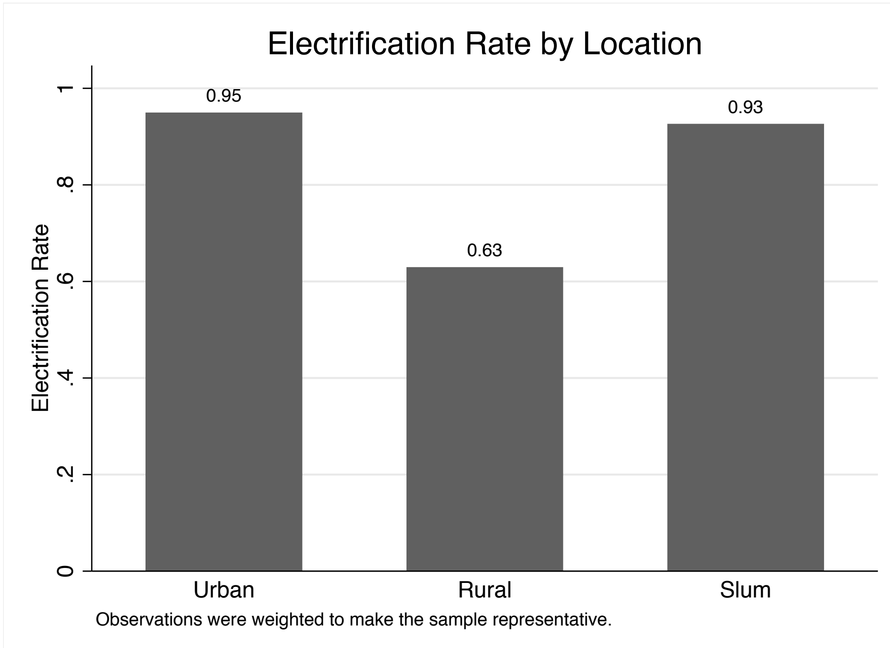

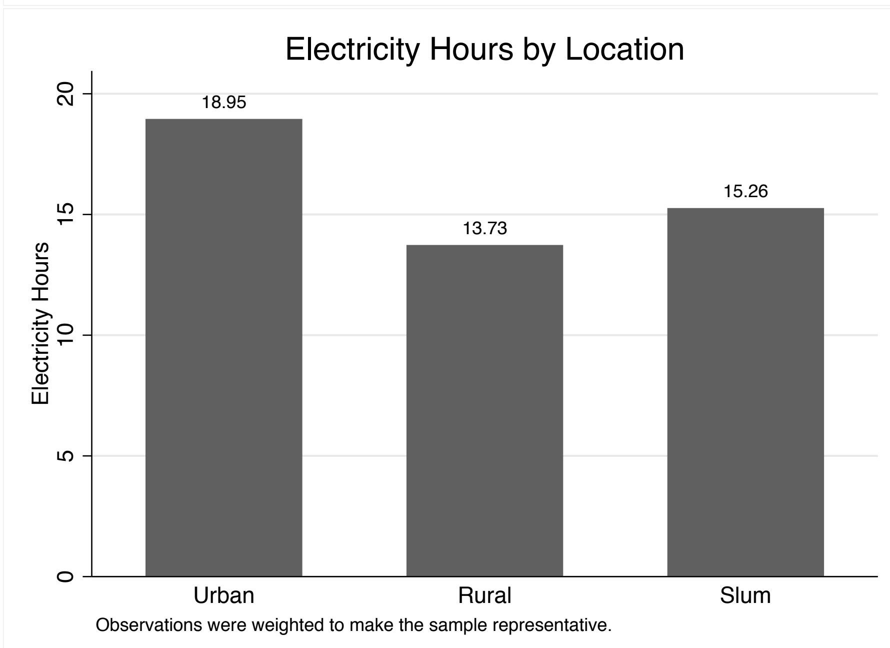

Figure 1: Electrification Rate and Hours of Electricity by Location. Each observation was weighted to make the sample representative.

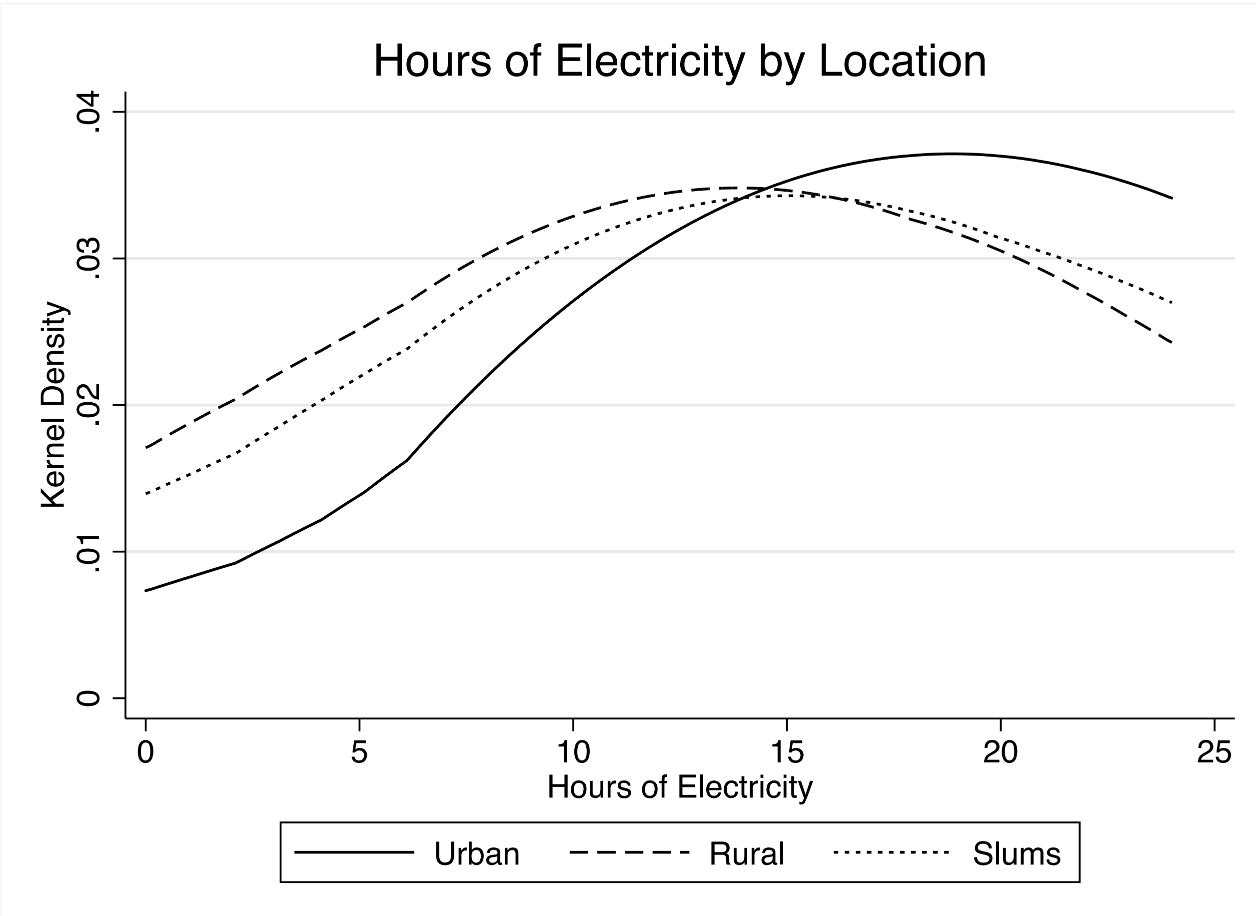

Figure 2: Distribution of Hours of Electricity by Location.

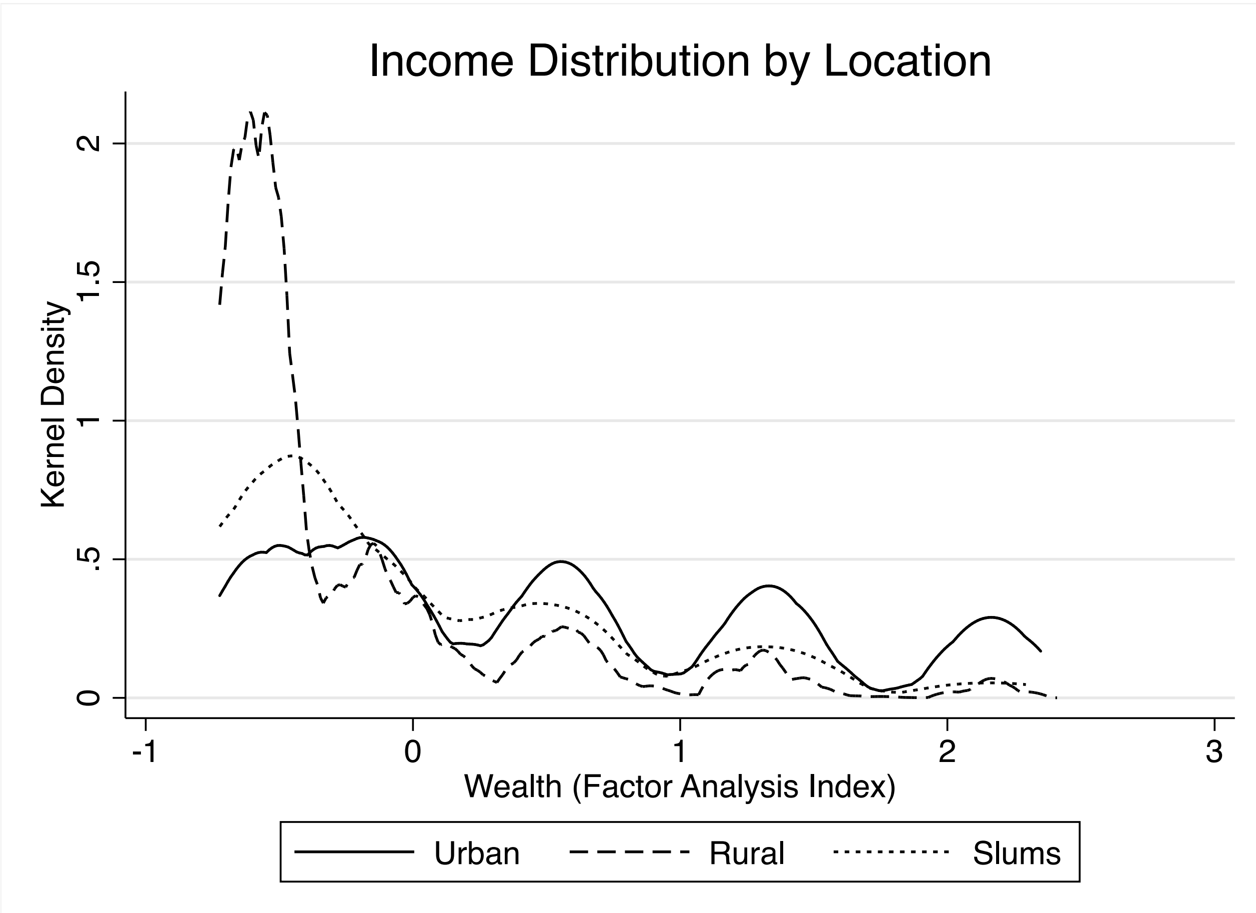

Figure 3: Distribution of Income by Location.

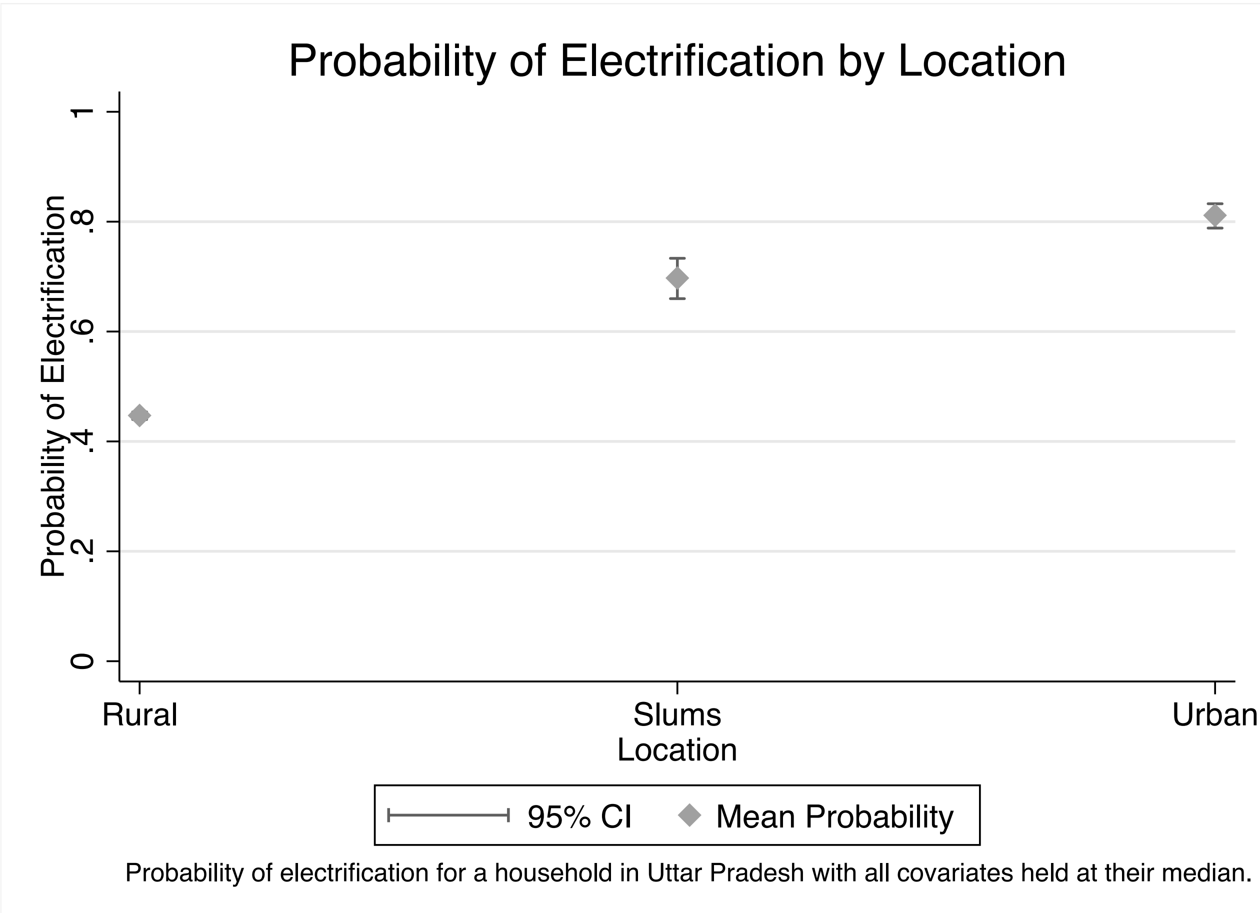

Figure 4: Likelihood of Having Electricity: Simulation.

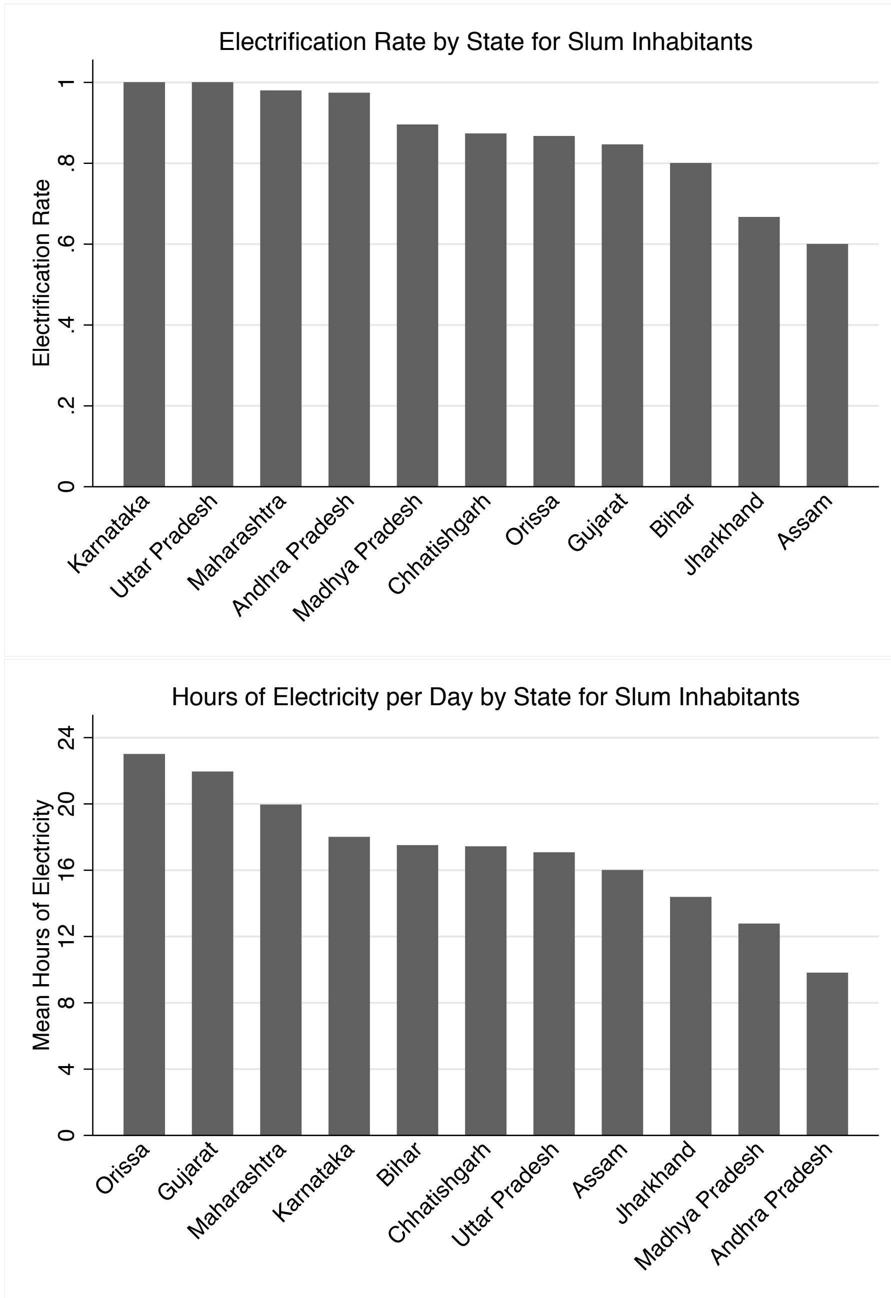

Figure 5: Electrification Rate and Hours of Electricity by State for Slums Inhabitants. Each observation was weighted to make the sample representative.

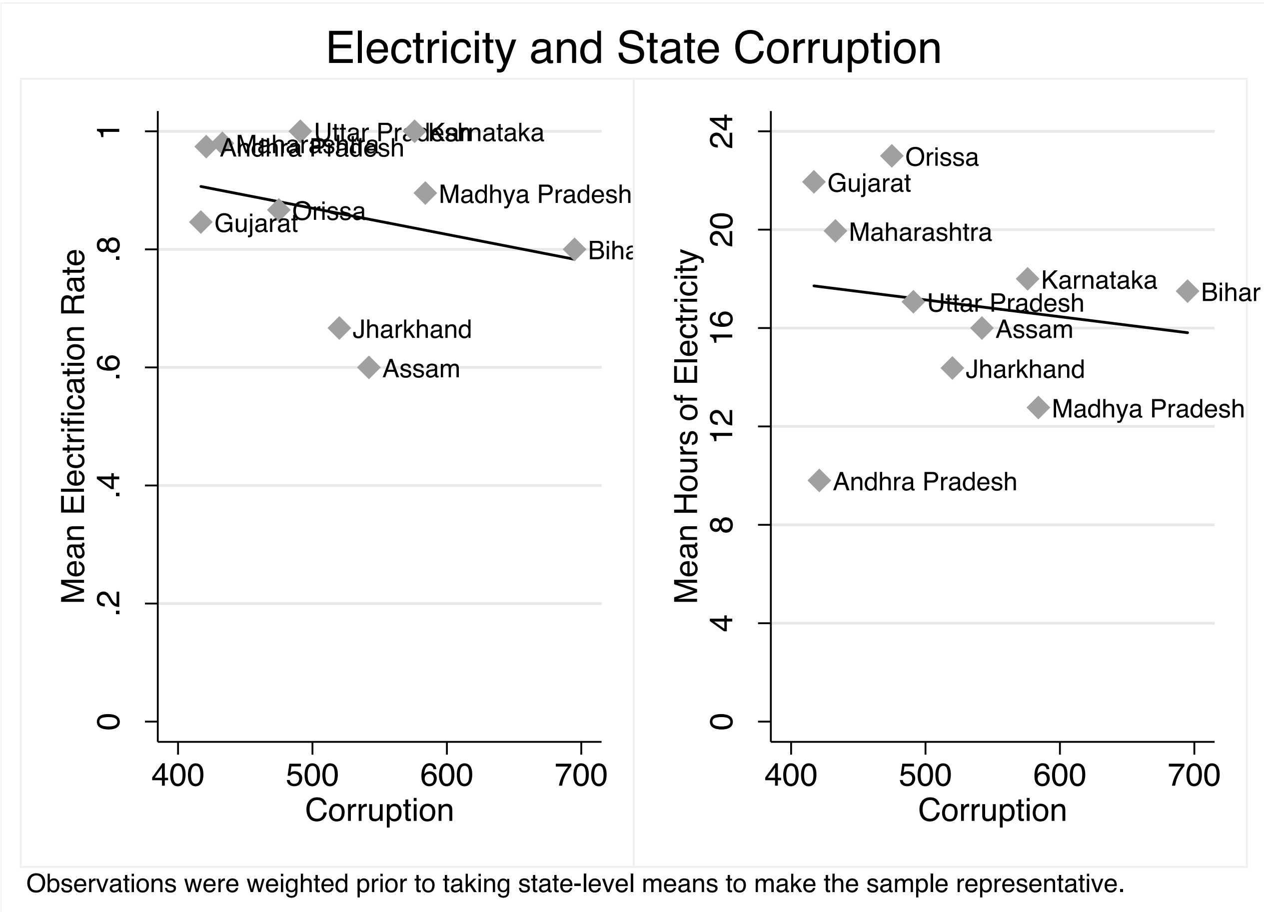

Figure 6: Electrification Rate and Hours of Electricity by State Corruption. Each state has its own corruption score based on data from Transparency International (2005). The average electrification rate and hours of electricity are computed for respondents living in slums in each state. When taking averages, each respondent is weighted based on the weights provided by the survey.

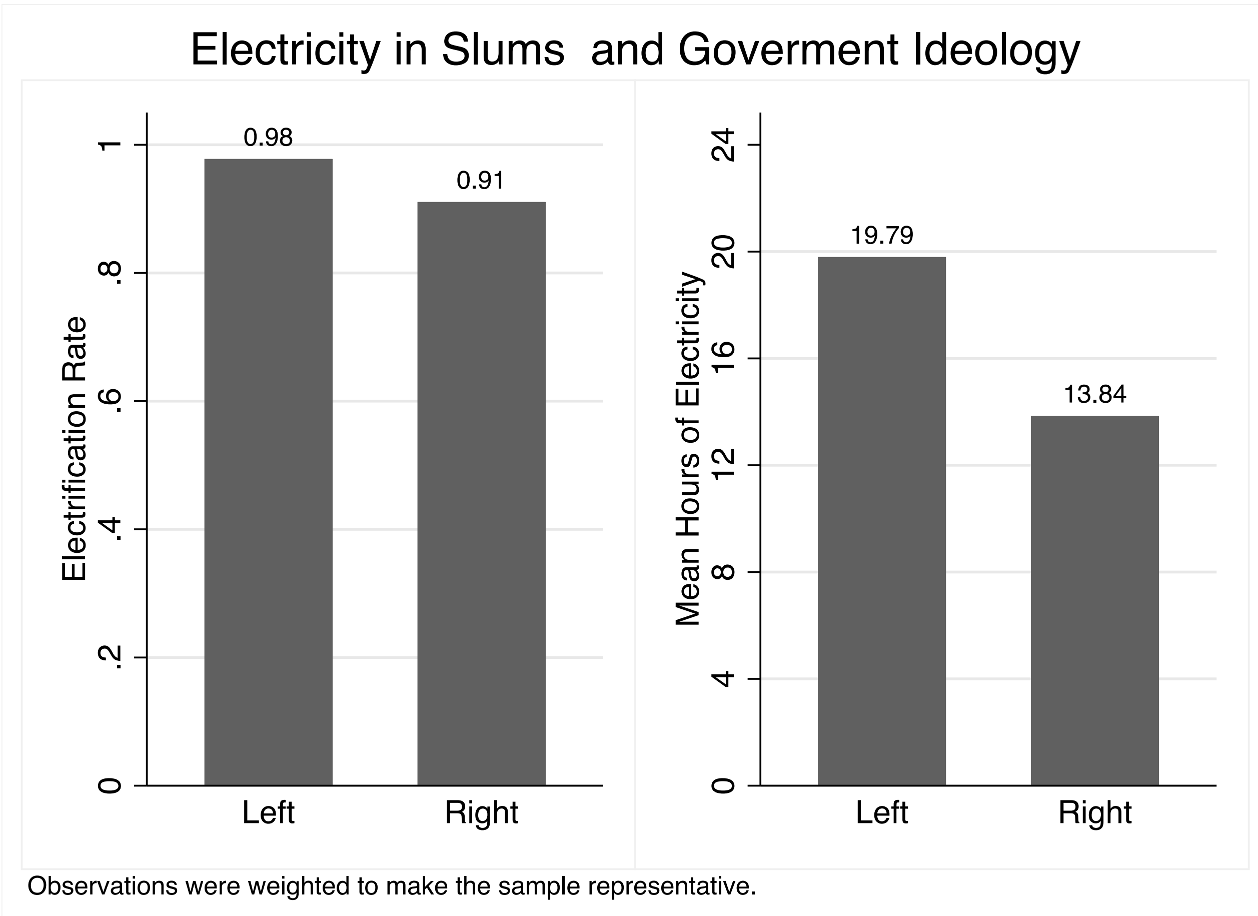

Figure 7: Electrification Rate and Hours of Electricity by Ideology. Ideology was computed as follows. First, starting in 1990, each government was given an ideology score between 1 and 5 (the score goes up as the ruling party is more to the left). Then, this score was averaged by state over the 1990-2004 period. The sample was then divided between states that were relatively to the right (ideology score below the median) and those that are relatively to the left (ideology score above the median). Finally, the average electrification rate and hours of electricity are computed for respondents living in slums in either type of states.

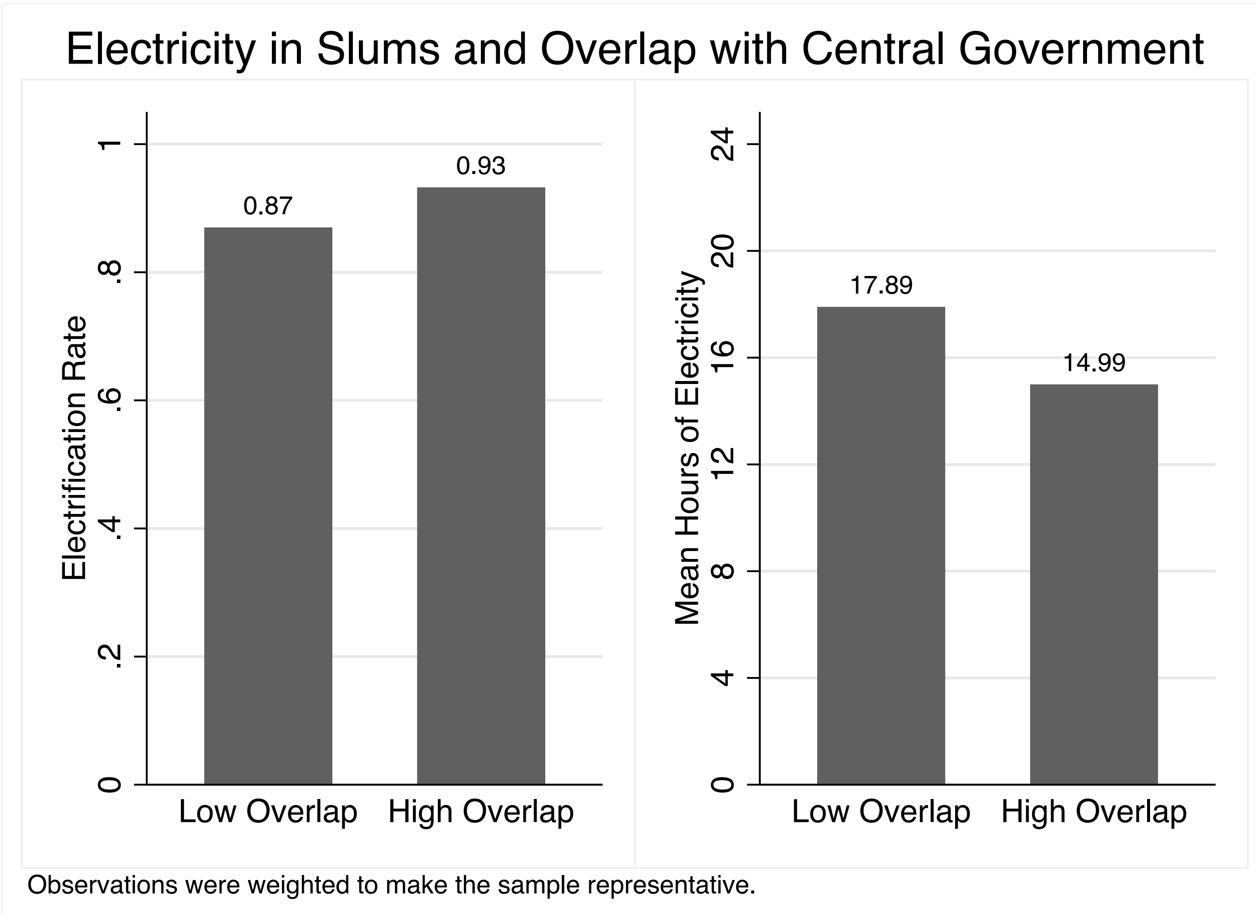

Figure 8: Electrification Rate and Hours of Electricity by Overlap with Central Government. Overlap was computed as follows. First, starting in 1990, a dummy variable flagged every year in which the ruling party at the state level was the same as the ruling party at the national level. Then, this variable is summed up over the 1990-2004 period. Thus, overlap means the number of years in which the ruling elites overlap at the state and national level. The sample is then divided between those that have an overlap score below and above the median. Finally, the average electrification rate and hours of electricity are computed for respondents living in slums in either type of states.

	Mean	Mean	Min	Max	Obs
Rural					
Electricity	0.63	0.48	0	1	26759
Hours of Electricity	13.73	7.45	0	24	19792
Wealth Index	-0.31	0.56	-1	2	26736
Agriculture	0.59	0.49	0	1	27011
Education	6.12	4.93	0	15	26968
Household Size	5.32	2.62	1	38	27011
Urban					
Electricity	0.95	0.22	0	1	13766
Hours of Electricity	18.95	5.96	0	24	13142
Wealth Index	0.47	0.90	-1	2	13672
Agriculture	0.08	0.27	0	1	13817
Education	9.83	4.63	0	15	13806
Household Size	4.82	2.14	1	28	13818
Urban Slum					
Electricity	0.93	0.26	0	1	723
Hours of Electricity	15.26	7.60	0	24	681
Wealth Index	0.06	0.73	-1	2	717
Agriculture	0.06	0.24	0	1	725
Education	7.35	4.58	0	15	725
Household Size	5.38	2.10	1	17	725
Total					
Electricity	0.72	0.45	0	1	41248
Hours of Electricity	15.50	7.41	0	24	33615
Wealth Index	-0.10	0.75	-1	2	41125
Agriculture	0.45	0.50	0	1	41553
Education	7.11	5.11	0	15	41499
Household Size	5.19	2.51	1	38	41554

Table 1: Summary Statistics (weighted)

	(1) Logit	(2) Logit	(3) Logit	(4) Logit	(5) OLS	(6) OLS	(7) OLS	(8) OLS
Rural	-1.997***	-1.470***	-1.038***	-1.062***	-1.530	-2.038	-1.738	-1.246
	(0.388)	(0.285)	(0.275)	(0.293)	(2.199)	(1.927)	(1.973)	(2.026)
Urban	0.404	0.928***	0.663**	0.610*	3.692*	2.227	1.952	1.862
	(0.351)	(0.320)	(0.326)	(0.313)	(1.998)	(1.829)	(1.907)	(1.909)
Wealth Index			2.259***	1.790***			0.861***	0.525***
			(0.186)	(0.198)			(0.119)	(0.123)
Agriculture				0.021				-0.866***
				(0.099)				(0.219)
Education				0.115***				0.125***
				(0.013)				(0.031)
Household Size				-0.002				-0.021
				(0.015)				(0.036)
Constant	2.526***	3.641***	3.694***	2.920***	15.256***	23.553***	23.441***	21.986***
	(0.331)	(0.282)	(0.293)	(0.340)	(2.152)	(1.927)	(1.947)	(1.949)
State Fixed Effects		✓	✓	✓		✓	✓	✓
Observations	41248	40993	40596	40546	33615	33615	33262	33218

See text for the dependent variables.

The omitted category is slum.

Standard errors clustered by state. Weighted responses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Main Results.