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Electrification and welfare for the marginalized: Evidence from India

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ABSTRACT

Uneven electrification can be a source of welfare disparity. Given the recent progress of electrification in India, we analyze the differences in access and reliability of electricity, and its impact on household welfare for marginalized and dominant social groups by caste and religion. We carry out longitudinal analysis from a national survey, 2005–2012, using OLS, fixed effects and panel instrumental variable regressions. Our analysis shows that marginalized groups (Hindu SC/ST and Muslims) had higher likelihood of electricity access compared to the dominant groups (Hindu forward castes and OBC). In terms of electricity reliability, in a period when the all households lost electricity hours, marginalized groups lost less electricity hours in a day as compared to dominant groups. Results showed that electrification enabled marginalized households to increase their consumption, assets and move out of poverty, but the effect was smaller as compared to dominant groups. Overall, the effects were more pronounced in rural areas. The findings are robust to alternative ways of measuring consumption, and other robustness checks. We posit that electrification increased household welfare of marginalized groups, but did not reduce absolute disparities among social groups.

1. Introduction

The issue of socio-economic disparities between the dominant and marginalized groups has been widely documented in India (Thorat and Neuman, 2012; Dreze and Sen, 2013; Thorat et al., 2017; Zacharias and Vakulabharanam, 2011), however, less is understood about the effects of public policies on these disparities, (Aklin et al., 2020; Kennedy et al., 2019; Pelz et al., 2020). Marginalized groups[1] face higher risk of falling into poverty as inter-group differences consistently persist, even during phases of growth and development (Thorat et al., 2017; Pueyo et al., 2020). These inter-group inequalities in both private and public distribution hamper 'social empowerment', a notion essential to the fabric of inclusive growth.[2]

In recent years, public policies in India have set targets to improve employment opportunities and infrastructure for the 'poor' and the disadvantaged (Saxena and Bhattacharya, 2018; Kemmler, 2007). One such public policy has been the 'electrification drive' in India that started with the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), 2005, with strong impetus on the electrification of unelectrified households (Rao, 2013; Khandker et al., 2014; Sedai et al., 2020a). Since 2014, the program changed political hands, and is currently being carried out as the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY), with the objective to electrify all unelectrified households by 2022, and improving the quality of elec- tricity post-electrification (Rathi and

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[1] Social organization based on caste and religion in India differs in its structure from 'ethnic' or 'race' segregation. The caste structure transforms the horizontal and unconnected co-existences of ethnically segregated groups into a vertical social system of super-ordination and sub-ordination (Gerth and Mills, 2014). Based on religious marginalization, Hindus are a majority, and Muslims are a minority. Therefore, in our study, the marginalized groups are Hindu SC/ST and Muslims (analyzed separately), while the dominant groups are Hindu forward castes and Other Backward Caste.

[2] In addition, societal discrimination limits individual achievements due to enduring 'stereotype threats' despite the removal of legal barriers (Hoff and Pandey, 2006). For instance the continued link between caste, structural inequities and poverty despite the prohibition of discrimination against an Indian citizen due to their caste in 1950 (Hoff and Pandey, 2006; Pelz et al., 2020).

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Vermaak, 2018; Burgess et al., 2020).[3] The thrust on electrification since 2005, especially in rural areas (Rao, 2013), provides an opportunity to examine the likelihood of electrification, and its effect on welfare outcomes for the dominant and marginalized groups.

Available studies on the nexus of caste and electrification have focused only at the extensive margin—i.e., the likelihood of electricity access for marginalized caste groups. So far, empirical examinations have used either cross-section estimations at the national level or village and household fixed effects analysis at the regional level to quantify the likelihood of electricity access for the marginalized groups.[4] These studies have generally found that marginalized communities, at best, did not have a higher likelihood of electrification as com- pared to the dominant groups. However, so far, a national level longitudinal examination of the causal effects of the electrification drive on household electrification (both access and reliability) for marginalized groups has remained elusive. In addition to the lack of a na- tional study on electrification, there are two major gaps in the literature in understanding the nexus of caste and electrification: (i) an examination of the intensive margin of elec- tricity reliability (electricity hours available in a day)[5], and (ii) an analysis of utilization of household electrification for welfare gains in terms of household consumption, wealth and status of poverty for marginalized groups.

The above mentioned gaps in the literature need to be examined because: (i) studies have found massive redistribution and lack of electricity hours at the household level despite the progress in providing electricity connections (Sedai et al., 2020a; Aklin et al., 2020).[6] Lack of study at the intensive margin of supply could possibly overestimate the effect of the extensive margin of electricity access (Sedai et al., 2020a). Aklin et al. (2020) found that the poor quality of electricity connection in rural areas was driven by socio-economic inequalities and political motivations,[7] (ii) electrification is only a means to welfare, the utilization of the available electricity matters given the socio-economic constraints faced by marginalized communities. In this context, electrification in poor and disadvantaged rural areas does not entail reduction in socio-economic inequalities if the welfare effects are not materialized for marginalized groups, (iii) the lack of a national study masks the policy effort by the central government due to political motivations at the state level (Joseph, 2010; Baskaran et al., 2015; Allcott et al., 2016).[8] In addition to the above mentioned gaps in the literature, it is critical to study the performance during the initial period of reforms, this is because there could be frictions in policy efforts with changing political regimes, as has been argued to be the case in India by Baskaran et al. (2015).

Thorat et al. (2017) argue that there are unobservable social constraints in accessing technologies for the marginalized groups, therefore, the likelihood of electrification and its effects on household outcomes may be context dependent, and may not be fully explained by observable factors such as: geography, income and education levels. Given the unobserved factors, a robust analysis electrification outcomes requires capturing the correlation between the error term and the time-variant unobserved heterogeneity. A longitudinal analysis is also critical especially during the electricity reforms period (2005-present) where other major public policies (such as the employment guarantee program, 2005 and the global recession in 2008) could have affected household outcomes (Imbert and Papp, 2015). These macro level changes along with micro shocks (rainfall, health and regional shocks) to households, which are hard to account for, could have differently affected the likelihood of electrification, and its effect on household outcomes at various socio-economic levels.

There have been contradicting results in the effects of electrification on household outcomes. Some studies have found strong effects of electrification on individual and household welfare outcomes[9], while others have found little to no effect.[10] Given the mixed results of the effects of electrification on welfare outcomes, and the disproportionate likelihood of electrification for the disadvantaged groups concentrated in rural areas (Rathi and Vermaak, 2018; Dugoua et al., 2017; Pelz et al., 2020), it is crucial to examine how the marginalized groups performed in comparison to the dominant groups in terms of the likelihood of electrification, and in utilizing household electrification for welfare gains, expressed as increases in household consumption, wealth, and transitioning out of poverty. The study is relevant from a policy perspective as the sustainable development target of reducing energy poverty entails reducing disparity in access of sustainable energy for the poor and the disadvantaged (Sedai et al., 2020a). In addition, the ultimate objective of welfare in terms of higher consumption, reduction in poverty reduction and inequality are a part of the sustainable development goals.

Our study addresses the above mentioned gaps by examining differences in electricity access and reliability along with post electrification outcomes at the national level between 2005 and 2012. We do this by categorizing Hindus and Muslims differently. The forward caste and other backward caste (OBC) Hindus are categorized as the dominant groups, Hindu scheduled caste (SC), scheduled tribe (ST) are categorized as marginalized groups, and Muslims are categorized separately, as

[3] Although both policies do not directly address the marginalized groups in India, the objectives of providing electrification to the poor at a subsidized rate indirectly affects the disadvantaged groups compared to others (Pelz et al., 2020).

[4] see (Dugoua et al., 2017, Saxena and Bhattacharya, 2018, Aklin et al., 2020, Pelz et al., 2020).

[5] Hours of electricity available on a typical day is argued to be main determinant of satisfaction with electricity (Aklin et al., 2016). Electricity reliability is a major concern causing social unrest in India, and despite the willingness to pay, an average household in India has electricity for typically 60% of the day (Aklin et al., 2016; Sedai et al., 2020a).

[6] Census data show that the percentage of households with electricity access increased from 56% to 67% between 2001 and 2011, in rural areas from 43.5% to 55.3%. From 79% to 89% in a national survey (Sedai et al., 2020a). More recently household survey of six poorest state indicates an increase in electrification 66% in 2015 to 85% in 2018 (Sedai et al., 2020a).

[7] While RGGVY and DDUGJY have increased electricity connections tremendously, available infrastruc- tures to deliver reliable electrification are weak (Allcott et al., 2016, Chindarkar and Goyal, 2019). The lack of supply quality entails rationing of electricity supply hours to households (Kennedy et al., 2019). (Saxena and Bhattacharya, 2018) argue that it is not uncommon for many villages and also urban areas to be supplied with electricity for only a few hours in a day. As such, existing socio-economic disparities might have a major influence on who gets higher hours of electricity supply.

[8] A national analysis is critical as the electrification drive is based on center-state collaborations. Political motivations at the state level may bias the results—some states driven by electoral gains and populist policies might do better than other (Baskaran et al., 2015). Also in context of marginalized groups, choosing a few states might not fully represent the socio-economic inequalities as social organizations differ by state and regions in India due to cultural, historical and political reasons (Thorat and Neuman, 2012)

[9] For example, see (Dinkelman, 2011, Sedai et al., 2020a, Churchill and Ivanovski, 2020, Allcott et al., 2016, Rao, 2013, Khandker et al., 2014, Samad and Zhang, 2019, Sedai et al., 2020b, Chakravorty et al., 2014).

[10] For example, see (Burlig and Preonas, 2016, Lee et al., 2020).

marginalized groups because of their minority status in India.[11] Unlike previous studies which have only focused on the likelihood of electrification and have remained agnostic about the reliability, we focus on causal estimation of both the intensive and extensive margins of electrification. We also analyze the likelihood and reliability of electrification by sub-grouping the national effect into seven regions which allows us to infer about the regional variations in electrification outcomes for the marginalized groups. For the analysis of electrification as a means, we use panel fixed effect regressions to analyze the welfare outcomes for the marginalized groups, and compare it to dominant groups.

For this study, we use a balanced sample of individuals from the two waves of India Human Development Survey (IHDS), 2005–2012. First, for the analysis of the likelihood of electrification (electricity as an outcome), we use ordinary least squares (OLS), panel fixed effects, and panel fixed effects instrumental variable regressions with standard deviations clustered at the individual level. As Burlig and Preonas (2016), Dang and La (2019) and Sedai et al. (2020a) have argued, electrification (access and reliability) is non-random and is endogenous to household outcomes, such as household consumption. Therefore, we use 'ownership of motor vehicles' as an instrument—one that affects household consumption, but presumably does not affect household's access and reliability of electricity (Saxena and Bhattacharya, 2018). For the second analysis of the effects of electricity access and reliability (hours) on household's annual consumption expenditure, wealth (proxied by total assets) and poverty, we use panel fixed effects regressions to estimate the effect of electrification controlling for household's income, age of the respondent, highest adult education in the household, and size of the household.

With regards to the likelihood of electrification, our analysis shows that the marginalized communities (SC/ST/Muslims) benefited more compared to dominant groups in terms of access to electricity. However, Muslims were worse off compared to Hindu SC/ST groups in terms of electricity access. During the survey period, 2005–2012, when household electricity hours reduced on average at the national level,[12] marginalized groups experienced lower reductions in electricity hours as compared to dominant groups. Hindu SC/ST had a smaller decline in electricity hours compared to forward caste Hindus, while Muslims had a higher decline compared to both the Hindu SC/ST and forward castes. The results were stronger and significant in rural areas, but weaker and insignificant in urban areas. At the regional level, there were marked differences–eastern, western and southern regions saw a higher increase in electricity access as compared to other regions.

With regards to electricity as a means to welfare, our analysis of the effects of electricity access on household welfare shows that electricity access significantly increased the annual household consumption expenditure, assets, and reduced poverty for both the dominant groups as well as the marginalized groups. However, the effects were stronger and more significant for the dominant groups. Hindu forward caste saw a higher increase in overall household assets followed by Muslims and then Hindu SC/ST. Electricity reliability had similar effects on household consumption expenditure for the Hindu SC/ST and forward castes, but did not have a significant effect on Muslims. In terms of major electricity based appliances, Hindu SC/ST and Muslims had a stronger effect with electricity reliability, but the same was not true for electricity access.

[11] Although the Muslim population is categorized into all the four caste groups, however, due to data limitations, for the national level analysis, we categorize Muslims as marginalized groups primarily because they are minority in terms of population, and are generally socio-economically weaker than other religions in India. In the analysis, we do segregate marginalized groups with and without the sample of Muslim individuals.

[12] See Sedai et al. (2020a), Sedai et al. (2020b), Aklin et al. (2016).

2. The caste context of electrification

In India, despite substantial improvements in income levels among all population groups, poverty remains concentrated among the most traditionally disadvantaged groups (Jaffrelot, 2006). For instance, in the most progressive period of India's economic growth, 2004–2012, forward and OBC castes had their poverty rates fall almost in half, while for Dalits and Adivasis (SC/ST), poverty declined by a little over a third (Thorat et al., 2017). Despite major reductions, poverty levels are still high for the Adivasis (Jaffrelot, 2006; Thorat et al., 2017). With 'untouchability' still in practice and persistent caste based socio-economic inequalities[13], public programs, such as the employment guarantee program and the electrification drive by the government have a significant role to play in reducing these socio-economic disparities.

In general, the idea that social inequality and discrimination could affect electricity provisioning and utilization has not received due attention in the literature. The earliest study on caste based inequities in access to electricity was carried out by Kemmler (2007). The study uses a utility based binary choice model of having or not having electricity depending on the benefits to electricity derived by households. The study tested the hypothesis of benefits based choice of electrification using a cross sectional unit-level household budgets from the consumer survey of the 55th round of the National Sample Survey (NSS). Using probit regression, the study found that the SC and ST groups had a negative likelihood of −0.14 pp. and − 0.15 pp., respectively, of electrification. These results although being the first of its kind, had many caveats,[14] which more recent studies have attempted to address. Dugoua et al. (2017) addressed the issue of caste-based social exclusion by looking at the differential effect of the RGGVY on the likelihood of electrification by caste groups at the village level for six relatively poorer states in India,[15] and Aklin et al. (2020) looked at the caste based electrification rate in Uttar Pradesh between 2001 and 2011. Both studies found that the likelihood of electrification was significantly higher for villages with more forward caste communities than Dalit (SC) communities. Dugoua et al. (2017) used fixed effects analysis by clustering the standard errors at the village level, and showed that the likelihood of electrification was lowest and negative for villages mostly inhabited by Dalits, significant and positive for villages mostly inhabited by OBC, but weaker than the villages mostly inhabited by the forward caste. Using data from a hundred thousand villages, Aklin et al. (2020) find evidences of unequal caste outcomes in electrification. They find that despite political representation, villages inhabited solely by Dalits (Scheduled Caste) in Uttar Pradesh were 20% less likely to be covered by the program than villages without any Dalits. Interestingly, in terms of electricity reliability, Dugoua et al. (2017) find that for electrified villages, an increase in the population of lower caste households increases the reliability of household electricity supply. They argue that 'hours of electricity available depend largely on the supply of power to the rural feeder connected to the village, so that caste discrimination at the village level would be very difficult in practice' (p. 281).

More recently, Saxena and Bhattacharya (2018) posited that caste based residential segregation is a strong determinant of electricity consumption. Their study argues that marginalized households being

[13] The 2011–2012 India Human Development Survey shows that 41% of non-Dalit rural households across the country practice "untouchability", while 38% of Dalit rural households reported experiencing caste discrimination (Desai and Vanneman, 2018).

[14] Namely, the issue of cross-sectional simultaneity bias, exclusion of Muslims as marginalized groups, lack of examination of recent thrust on electrification for the poor, and utilization of electricity for household welfare.

[15] Their study matched the villages from the 2011 census to the Access to Clean Cooking and Energy Services Survey, 2015, using matching algorithms, for details, see (Dugoua et al., 2017). The data set they use is cross-sectional at the household level and acts as a 'pseudo-panel' for the village level analysis.

socio-economically weak compared to the upper caste households mostly reside in segregated hamlets in rural areas, or poorer neighborhoods/slums in the urban areas. They argue that residing outside the main perimeter of the localities makes it possible to discriminate against them by the suppliers of the energy goods (Liquified Petroleum Gas and electricity). Saxena and Bhattacharya (2018) use a crosssectional instrumental variable estimation technique with data from the 2011–2012 NSS consumer expenditure survey of electricity usage in Kilo Watt hours for the SC/ST and Muslims. They use the ownership of cars/jeep as an instrument that affects household's total consumption expenditure (used as a covariate) but does not affect electricity usage. Their analysis finds that being an ST household reduces electricity consumption by 10%, being an SC household reduces the same by 5.6%, while the coefficient for Muslims was small and insignificant.

Kennedy et al. (2019) found that, in general, electrified villages in India have a lower proportion of scheduled caste population, and the likelihood of disadvantaged caste households not being electrified is 10 percentage points higher than the likelihood of being electrified. Interestingly, when Kennedy et al. (2019) move from an OLS model of willingness to pay for electricity to a Heckman selection model with the first stage being the likelihood of having an electricity connection, they find that being a member of a disadvantaged caste increased the probability of having an electricity connection.

Recent study by Pelz et al. (2020) used the panel survey of rural North India (ACCESS, 2015–2018) and applied linear regression techniques with household fixed effects to examine the electricity connection for households belonging to Scheduled Caste and Tribes. Their study found no effect on SC/ST households on the likelihood of electricity connection through the grid. They found that the SC/ST groups did not benefit more than the dominant groups from the DDUGJY in terms of grid based electricity connection. Their analysis, for a relatively short period of time 2015–2018, and only for six states in India, does not capture the full extent of the effect of electricity reforms at the national level, and could be masked by political motivations in the said states, as argued by Baskaran et al. (2015).

Electrification matters, but it is only a means to welfare (Burlig and Preonas, 2016; Harish et al., 2014). Post electrification decisions that could alter time-allocations to home production and labor supply such as appliance usage or work during the night have been found to be dependent on income levels, education and social norms (gender and caste), as such having electricity is neccessary but not sufficient for determining household welfare (Sedai et al., 2020b; Winther et al., 2017; Thorat and Neuman, 2012). Burlig and Preonas (2016) used the variation in electrification rates with the RGGVY and found that electrification at best did not have any effect on a range of outcomes, including employment, asset ownership, housing stock, village-wide outcomes, household wealth, and school enrollment.[16] Encouraging patterns of electrification hide considerable variation across caste in India (Dugoua et al., 2017). On the one hand, electrification stands to benefit those who have existing social capital to utilize electricity for their gains, mostly the rich, and large farm-owning rural households (Khandker et al., 2014; Rao, 2013), while on the other, improved quality of electricity in the household stands to increase the consumption of the poor relatively more than the rich, especially in rural areas (Sedai et al., 2020a).

As caste-based inequalities are a historical phenomenon (Thorat and Neuman, 2012), cross sectional, regional or village level analyses are bound to overestimate or bias the effect at any point of time (results may show forward caste doing better in electrification compared to other caste). Capturing the time-variant and invariant unobserved heterogeneity is critical for individuals from a caste context, as (i) attributes of individuals/households based on their caste groups are fixed and are important in shaping their lifetime outcomes, and (ii) major economic and socio-political developments affect socio-economic outcomes overtime. Village and district level fixed effect analyses ignore the co-existence of multiple caste groups (for example, marginalized caste households in a dominant caste habituated location) within an area, and the changing population dynamics of an area.

Our longitudinal study at the national level with individual fixed effects and instrumental variables captures the unobserved heterogeneity and uses information from all households in all areas, regardless of marginalized or dominant groups. In addition, we use standard errors clustered at the individual level which allows for robust estimates. This is critical for both electricity distribution and utilization as there are socio-economic and political disparities in electrification, and socio-economic constraints post electrification at an individual and household level (Sedai et al., 2020a; Khandker et al., 2014; Winther et al., 2017; Joseph, 2010; Burgess et al., 2020). Panel fixed effects instrumental variable regressions allows us to capture the non-randomness in the likelihood of electricity and examine the effects of treatment effects in reducing caste inequalities in electrification. Once we control for the correlation between the error and the unobserved heterogeneity, the issue of endogeneity can is attenuated.

3. Data

The data used for our analyses is derived from the individual level nationally representative India Human Development Survey, the second and third wave 2005 and 2012, respectively (Desai and Vanneman, 2018). IHDS provide nation-wide caste-desegregated samples. The survey is jointly carried out by researchers from the University of Maryland and the National Council of Applied Economic Research in New Delhi. IHDS covers wide-ranging topics at the individual and household level on demographic and socio-economic characteristics and observations are available by their caste groups. One caveat in the use of IHDS for caste based analysis is that the all Muslim population in the longitudinal data available are a separate group and are not classified into any social/caste group (Desai and Vanneman, 2018). Classification of Muslims in caste groups is masked in the data for privacy which restricts incorporating Muslims into caste groups. Therefore, this limitation restricts a clear caste based analysis of the entire sample.

Before we begin the analysis, we create an analytically balanced sample with observations in both rounds, as only 83% of the observations are matched in the raw panel of the IHDS (Desai and Vanneman, 2018). We drop observations for the Sikh, Jains and Christians, which leaves us with the caste group for Hindus only, and Muslim as a religion separately. Therefore we loose a number of observations in creating a balanced sample for our analysis. Further, when we analyze the effects of electricity reliability, we condition our analysis on electricity access which further reduces the sample size. To begin with we have a sample of 301,966 observations (150,983 in each period). We drop the observations below 18 years, which leaves us with with a balanced sample of 91,831 observations in each wave. We then drop the observations for Christians, Sikhs and other religious minorities which leaves us with 88,142 observations for each period above the age of 18 years for the estimation of electricity access, and 66,002 observations each period for the estimation of electricity reliability.

Electricity access is derived from the questionnaire which asks respondents, "Does your household have electricity access". Electricity

[16] Similarly, Lee et al. (2020) questioned the use of instrumental variables, as the instruments might have effects on outcomes beyond the channel of electrification. Their analysis contests the welfare outcomes derived in Brazil, India, Nicaragua, South Africa and Kenya. To substantiate their argument they conduct a randomized controlled experiment in Kenya and find no impact of electrification on welfare outcomes.

reliability is measured conditional on electricity access[17] and is derived from the question, "How many hours of electricity is available in your household on a typical day". The above two variables are used as dependent variables for the first part of the analysis (electricity as a means). For the first analysis, the covariates used are individual's caste, and religion if Muslim[18] household annual consumption expenditure, household head's education, age in years, below poverty line card with the household (0/1), and household size. The annual household consumption expenditure in rupees is deflated using the IHDS deflator (see (Desai and Vanneman, 2018)) and then we take a natural log of the variable to look at the growth rate of the variable.

For the welfare analysis, the dependent variables are household consumption, assets and status of poverty. Log of household consumption expenditure is the same as used in the first analysis. We analyze assets as a proxy for wealth from the IHDS survey, which comprises of 30 durable assets[19] both electrical and non-electrical. In terms of the status of poverty, we use only the IHDS data to look at the likelihood of transitioning out of poverty with electrification. The IHDS data has the categorical variable poor and non-poor based on the 'Tendulkar poverty line'[20] (Desai and Vanneman, 2018).

4. Empirical framework

4.1. Likelihood of electrification

We first examine electrification as an outcome and analyze the likelihood and reliability of electrification for the marginalized groups using an OLS, fixed effects and fixed effects– instrumental variable regressions. The OLS model does not capture the correlation between the error term and the unobserved heterogeneity and acts as a pooled cross section model. The fixed effects model captures the time-invariant unobserved heterogeneity and similar to estimation model used by Pelz et al. (2020). Finally the instrumental variable regression captures all types of correlation between the error term and the unobserved heterogeneity, thus showing causal point estimates. The estimation model is as follows:

$$Y_{it} = \beta SC/ST_i + \alpha 2012_i + \delta SC/ST^{*}2012_{it} + X_{it}{'}\gamma + \sigma_f + E_{it} \tag{1}$$

For Muslims as a marginalized group we use the following model

$$Y_{it} = \beta Muslims_i + \alpha 2012_i + \delta Muslims^{*}2012_{it} + X_{it}{'}\gamma + \sigma_f + E_{it} \tag{2}$$

In Eq. 1, Y_{it} represents the outcome of interest for individual i at time t: electricity access and electricity reliability (hours of electricity available on a typical day) in the household. β captures the difference in the outcome between SC/ST households and all other Hindus in 2005.[21] α captures aggregate change in the outcome over time for all other households, and δ captures the difference in the outcome between 2005 and 2012 for SC/ST/Muslim households compared to the difference in the outcome over the same time period for all other households. $X'_{it}$is a vector of observable individual and household socioeconomic and demographic characteristics which are likely to affect household's access and reliability of electricity: household consumption, household head's education, age in years, ownership of a below poverty line card and household size. σ captures the individual fixed effects.[22] E_{it} is the error term with standard errors are clustered at the individual level. In addition to the estimates described above, we sum α and δ to estimate the absolute change in the outcome between 2005 and 2012 for SC/ST or Muslim households. This summation can be considered alongside α in order to compare absolute changes in outcomes across the groups between 2005 and 2012.

We use household consumption expenditure as a covariate in our analysis, as it is argued to be a critical factor affecting household decision to be electrified (Saxena and Bhattacharya, 2018; Sedai et al., 2020a). However, there is an issue of endogeneity involved when using household consumption expenditure as a covariate. The main argument for endogeneity bein that consumption and distribution of electricity are non-random, there is self-selection and sorting involved.[23] From a policy standpoint, Lee et al. (2020) argued that electricity grid infrastructures are costly and long-lived, their planning, allocation decisions and construction requires the inputs of multiple stakeholders, hence, it is rarely randomized, instead it is endogenous to a variety of economic and political factors' (p. 131). From the supply standpoint, Burlig and Preonas (2016) argue that energy infrastructure projects in developing economies target relatively wealthy or quickly-growing regions, while in contrast, Rathi and Vermaak (2018) and Sedai et al. (2020a) argued that the grid infrastructure expansion in India targeted the poor and the disadvantaged in rural areas. Dang and La (2019) argue that economic and infrastructural developments in districts could simultaneously affect electricity variables and household outcomes.

From the demand side, electrification decisions are dependent on household income, location, and social-cultural factors (Sedai et al., 2020b; Khandker et al., 2014; Dang and La, 2019). Households that are more willing to get electrified or purchase better quality of electricity (for instance, because they are richer or better educated)) are also more likely to live in areas that are better electrified or are less exposed to outages. Income effect could imply that higher employment or better economic outcomes (consumption expenditure) for the household could lead to an increase in demand and consequently higher consumption of electricity (Saxena and Bhattacharya, 2018). Endogeneity could be due to time-varying omitted variable bias motivated by unobserved factors at the household level (such as employment, income or health shock, etc.). Also, household's perception about potential benefits or costs of electricity could also affect household's decision to get electrified (Khandker et al., 2014). Selection of these kinds could bias econometric estimates of treatment effects. However. Therefore, while remaining agnostic about the nature of the self-selection bias, our empirical analyses seeks to address the possibility of endogeneity.

Given that the likelihood of electrification through program placements is non-random and not independent of households consumption

[17] This is because when we include households with no electricity access in the first wave and access in the second wave, the variation in electricity hours could be mostly driven by the movement from no access to access in the two waves. We wish to observe the variation for households that had access in both periods.

[18] The population of caste groups in the IHDS survey are representative of the national level population of various caste groups in India if we use the population weights (Desai and Vanneman, 2018). For summary statistics, we weight the sample using a population weighted measure, while for the regression analysis, we do not use the population weights.

[19] Assets: ownership of the house, bicycle, vehicle, sewing machine, generator set, mixer grinder, mo-tor cycle, motor vehicle, television, air cooler, air conditioner, clock/watch, electric fan, chair/table, cot, telephone, refrigerator, pressure cooker, dinner set, car, washing machine, computer, credit card, 2 clothes, footwear, water storage containers.

[20] Tendulkar poverty line categorized people earning less than Rs. 33 a day as poor in rural India and Rs. 38 a day as poor in urban India. The line is primarily meant to be an indicator for tracking progress in combating extreme poverty.

[21] In eq. 2, β captures the difference in the outcome between Muslims and all Hindus in 2005 in one specification, and between Muslims and Hindu SC/ST in 2005 in another specification. Similar analogy applies to all other parameters for 2.

[22] As a robustness exercise, we also carry the same analysis using village fixed effects.

[23] The issue of simultaneity bias between household income/consumption and electrification has been found to be true in many developing economies in Africa and Asia (Millien, 2019).

and income levels[24], we use the instrument 'ownership of motor vehicle', as also used by Saxena and Bhattacharya (2018) to control for the endogeneity between household consumption and electricity access. The instrument is argued to affect household's consumption expenditure, but is presumed to not affect households access and reliability of electricity (Saxena and Bhattacharya, 2018). We check for the validity of the instrument using the over and under identification criteria given by Staiger and James (1997), and various other tests for instruments given in the *xtoverid, nois* command in stata.

4.2. Electrification as a means

The second part of our analysis considers electricity as a means to household welfare (consumption, assets and status of poverty). To estimate the relationship between electricity (access and reliability) and household outcomes based on caste. We use fixed effects and fixed effects instrumental variable regressions to estimate the effects of electrification. The panel fixed effects model is as follows:

$$Y_{it} = \beta E_{it} + X_{it}' \delta + \theta_i + \gamma_t + E_{it} \quad (3)$$

where Y_{it} represents the outcome of interest for household i at time t: annual consumption expenditure, assets and status of poverty. E_{it} is the access/h of electricity in the household of individual i at time t. X'_{it} is a vector of individual and household observable socioeconomic and demographic characteristics: household wealth measured by total assets, education, age, below poverty line card, and household size. The unobserved θ_i is modeled as a fixed effect with no restriction on the correlation with other model regressors. γ_t is a survey wave intercept. The error term E_{it} is assumed to be randomly distributed.

5. Results

5.1. Descriptive statistics

5.1.1. Electricity access

Before discussing the results from regression analysis, we look at the state of electrification and associated covariates by social groups. Table 1 shows that between 2005 and 2012, households from all Hindu caste groups along with Muslims saw a increase in electricity access.

The increase in electricity access was highest for the ST groups, an increase of 19 pp. (61 to 80%), while forward caste households registered the smallest increase, albeit from a comparatively higher base as compared to the scheduled caste (90 to 95%). The OBC, SC and Muslims all saw relatively similar increases from relatively similar bases, 79–88%, 73–85%, 76–86%, respectively. During the period, 2005–2012, the RGGVY scheme had been implemented under the 10th plan (2002–2007) and the 11th plan (2007–2012), with 229 districts covered in the 10th plan and 331 districts covered in the 11th plan (Burlig and Preonas, 2016). Given the wide coverage of the RGGVY plan, and the statistics reported in Table 1, we can say that RGGVY was positively correlated with increasing electricity connections at the national level.

As found in the literature, forward castes in general have higher levels of household income and consumption as compared to the marginalized groups. The same is true for household head's education, household's assets. Marginalized communities are also relatively more poorer than the forward caste groups.

Table 2 shows that the lack of electricity access and reliability is more of a rural phenomenon in India. The table also shows that there has been relatively more improvements in electricity access in rural areas as compared to urban areas. ST groups had the highest improvement in electricity access in rural areas followed by Muslims and SC groups.

[24] See (Burlig and Preonas, 2016, Sedai et al., 2020a, Dang and La, 2019, Saxena and Bhattacharya, 2018).

Table 1
Summary Statistics by Caste for Hindus, and for Muslims, 2005–2012.

	Forward caste			OBC			SC			ST			Muslims		
		2005	2012		2005	2012		2005	2012		2005	2012		2005	2012
Variable	Obs	Mean		Obs	Mean		Obs	Mean		Obs	Mean		Obs	Mean	
Electricity Access (0/1)	20,538	0.90	0.95	31,941	0.79	0.88	17,985	0.73	0.85	6976	0.61	0.80	10,138	0.76	0.86
		(0.31)	(0.20)		(0.41)	(0.32)		(0.45)	(0.34)		(0.49)	(0.39)		(0.43)	(0.33)
Electricity Hours (0–24)	18,387	17.14	15.70	25,325	15.49	14.68	13,053	15.73	14.95	4262	14.83	14.72	7665	15.16	13.91
		(6.41)	(6.91)		(6.82)	(6.77)		(6.82)	(6.77)		(6.41)	(6.93)		(6.83)	(7.11)
Log real annual Con. Exp.	20,600	12.20	11.74	32,088	11.92	11.46	18,143	11.75	11.30	7009	11.46	11.12	10,215	12.00	11.60
		(0.68)	(0.68)		(0.70)	(0.69)		(0.66)	(0.65)		(0.73)	(0.72)		(0.69)	(0.69)
Log real annual hh Inc.	20,333	12.11	11.68	31,474	11.67	11.25	18,007	11.51	11.19	6922	11.40	10.95	10,103	11.74	11.36
		(1.01)	(1.08)		(1.01)	(1.06)		(0.90)	(0.92)		(0.99)	(1.08)		(0.95)	(0.98)
HH Head Education	20,623	10.42	11.03	32,086	8.18	8.71	18,119	6.59	7.43	7014	5.69	6.61	10,204	6.88	7.74
		(4.22)	(4.04)		(4.72)	(4.73)		(4.88)	(4.90)		(4.98)	(5.05)		(4.97)	(5.02)
Assets (0–30)	20,638	15.66	18.19	32,115	11.97	15.07	18,157	10.44	13.46	7014	7.92	10.93	10,218	12.09	15.15
		(5.78)	(5.42)		(5.62)	(5.82)		(5.48)	(5.63)		(5.00)	(5.83)		(5.62)	(5.64)
Poor	20,600	0.09	0.08	32,088	0.21	0.16	18,143	0.28	0.23	7009	0.46	0.36	10,215	0.27	0.18
		(0.28)	(0.27)		(0.41)	(0.36)		(0.45)	(0.42)		(0.50)	(0.48)		(0.44)	(0.38)
Age in years	20,638	40.55	47.81	32,115	39.49	46.71	18,157	38.15	45.33	7014	38.37	45.40	10,218	37.81	44.73
		(14.55)	(14.84)		(14.24)	(14.61)		(13.77)	(14.14)		(13.43)	(13.54)		(13.93)	(14.29)
Below Poverty Line Card	20,638	0.17	0.19	32,115	0.34	0.36	18,157	0.41	0.44	7014	0.50	0.51	10,218	0.29	0.32
		(0.38)	(0.39)		(0.47)	(0.48)		(0.49)	(0.49)		(0.50)	(0.49)		(0.45)	(0.46)
Household Size	20,638	6.04	5.41	32,115	6.27	5.49	18,157	6.04	5.39	7014	5.94	5.33	10,218	7.03	6.50
		(2.98)	(2.70)		(3.27)	(2.79)		(2.78)	(2.44)		(2.93)	(2.41)		(3.31)	(3.09)

Source: Authors elaboration, IHDS, 2005–2012. Standard deviations in parenthesis. Muslims is separately listed in the in IHDS, therefore we cannot disaggregate the Muslim group by caste. All castes listed are for Hindus. Observations for Sikhs, Jains and Christians are dropped from the summary statistics, and all consequent analyses.

Table 2
Descriptive Statistics of electricity access and reliability by social groups in rural and urban areas, India, IHDS, 2005–2012.

Variable	Urban					Rural				
		2005		2012			2005			2012
	Obs.	Mean	SD	Mean	SD	Obs.	Mean	SD	Mean	SD
Forward Caste										
Electricity Access (0/1)	8022	0.98	0.15	0.99	0.08	12,516	0.84	0.36	0.93	0.26
Electricity Hours (0–24)	7839	19.08	5.51	18.46	6.10	10,548	15.71	6.66	13.75	6.80
OBC										
Electricity Access (0/1)	8820	0.95	0.21	0.98	0.15	23,121	0.73	0.44	0.85	0.36
Electricity Hours (0–24)	8414	18.53	6.24	16.93	6.66	16,911	13.97	6.59	13.62	6.57
SC										
Electricity Access (0/1)	4630	0.90	0.30	0.96	0.20	13,355	0.67	0.47	0.82	0.38
Electricity Hours (0–24)	4171	18.60	5.93	17.96	5.91	8882	14.38	6.80	13.59	6.69
ST										
Electricity Access (0/1)	860	0.89	0.31	0.94	0.23	6116	0.57	0.49	0.78	0.41
Electricity Hours (0–24)	766	19.33	5.92	18.45	6.53	3496	13.84	6.08	14.04	6.78
Muslims										
Electricity Access (0/1)	4465	0.94	0.25	0.97	0.18	5673	0.62	0.49	0.79	0.41
Electricity Hours (0–24)	4175	16.43	6.69	16.14	6.36	3490	13.65	6.68	11.57	7.13

Source: Authors elaboration, IHDS, 2005–2012. The sample is balanced for households with electricity access in both the survey waves.

Barring the ST groups in rural areas, all other social groups registered a decline in electricity reliability in both rural and urban areas, the highest decline being for the OBC groups in urban areas and for the forward caste (Brahmins) in rural areas.

5.1.2. Electricity reliability

The picture of electricity reliability is contrasting to that of electricity access. This has been attributed to the lack of policy focus on the quality of electricity supply during the RGGVY scheme (Sedai et al., 2020a). Fig. 1 shows that between 2005 and 2012, Muslims and nearly all Hindu caste groups (except ST) saw a decline in electricity hours. The highest decline was for Muslims households and the smallest decline was for the forward caste.

To illustrate the lack of electricity access as of 2012, Fig. 2 shows the district wise distribution of household electricity hours in 2012. The figure underscores within state and regional variations, and the lack of reliable electricity across India. To illustrate the point of massive redistribution and the lack of household electricity hours further, Fig. 3 shows the difference in household electricity hours from 2005 to 2012. The figure shows that the overall redistribution was negative.

In terms of household electricity hours on a typical day, Table 1 shows that the forward caste groups on average were the biggest losers of electricity quality (1.44 h of electricity in a day) from 2005 to 2012. Both OBC and SC groups lost approx. 0.80 h of electricity in a day. Muslims lost 1.25 h of electricity in a day, while the least reduction was for the ST groups of 0.09 h of electricity in a day. The change electricity reliability did not quite follow the change in electricity access in rural and urban areas. While the change in electricity access was more prominently a rural phenomenon, change in electricity reliability was observed both more equally in rural and urban areas, albeit a stronger decrease in rural areas, on average. The higher decline in electricity reliability in rural areas during the period could be attributed to the lack of infrastructure to support the growing demand for electricity in rural areas (Kennedy et al., 2019; Aklin et al., 2020), more so in a time when electricity access increased rapidly.

5.2. Electrification as an outcome

5.2.1. Electrification as an outcome

In this section, we examine the likelihood of electricity access and reliability at household level nationally and by regions.[25] To discuss the significance of using fixed effects (capturing time-invariant unobserved heterogeneity) over the OLS estimation technique and the significance of using fixed effects instrumental variable strategy (capturing all unobserved heterogeneity) over the fixed effects and OLS, we compare the three estimations throughout the analysis. This strategy also lends robustness to our estimation.

For all analyses, we examine the likelihood of electrification separately for the marginalized groups (Hindu SC/ST and Muslims) and the dominant groups (forward caste Hindus). Muslims are a separate group and not accounted for in the caste structure. This is a major limitation in the longitudinal panel of IHDS derived from Desai and Vanneman (2018). However, as Muslims are a minority population group in India, we separately analyze Muslim household's electrification, and compare them to forward caste Hindus and marginalized Hindus.

Table 3 shows the likelihood of electricity access of the marginalized groups compared to all others. In column 1, 2 and 3 we look only the Hindu population. Here, 'SC/ST v Others Hindu (2012)' shows how much more or less likely were the Hindu SC/ST groups to get electricity access as compared to forward caste Hindus. In column 4, we look at the Hindu and Muslim population combined and see how much more or less likely were the Muslims to get electricity access as compared to all Hindu groups. In column 5, we look at how much more or less likely were Muslims to get electrified as compared to Hindu SC/ST groups.

In column 1, 2005 cross sectional estimate of −0.051 shows that SC/ST Hindus were 5.1 percentage points less likely to have electricity access as compared to forward caste Hindus if we looked at the cross sectional point estimate. However, from 2005 to 2012, the SC/ST groups had a higher likelihood of electricity access, 5.9 percentage points more than the forward caste groups. In absolute terms, SC/ST groups had a 17.7 (5.9 + 11.8) percentage percentage likelihood getting electricity access as compared to 11.8 percentage points of the forward caste groups.

[25] Note: in our analysis, we are not interested in tracking districts, the interest in this study is to analyze the likelihood of electrification (access and hours) during a period when massive electrification drive had taken place.

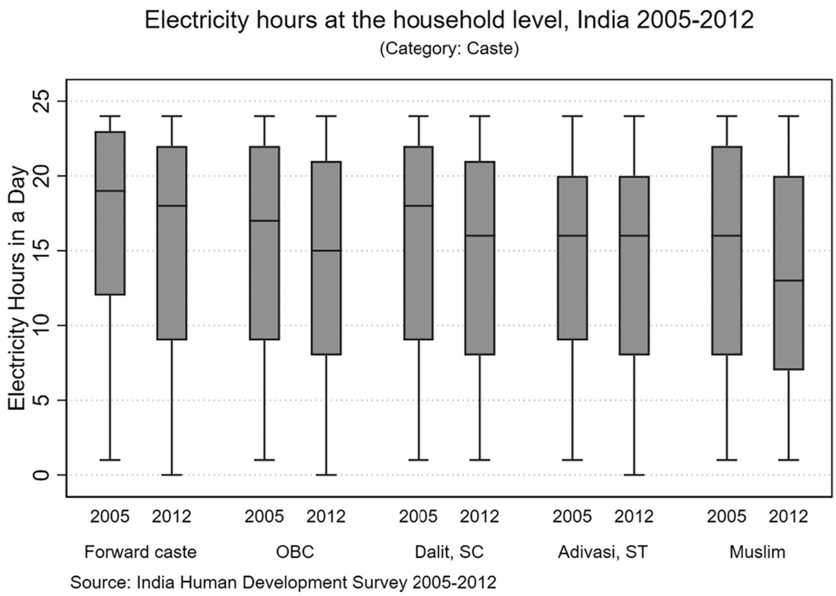

Fig. 1. Electrification hours at the household level in India, IHDS, 2005–2012.

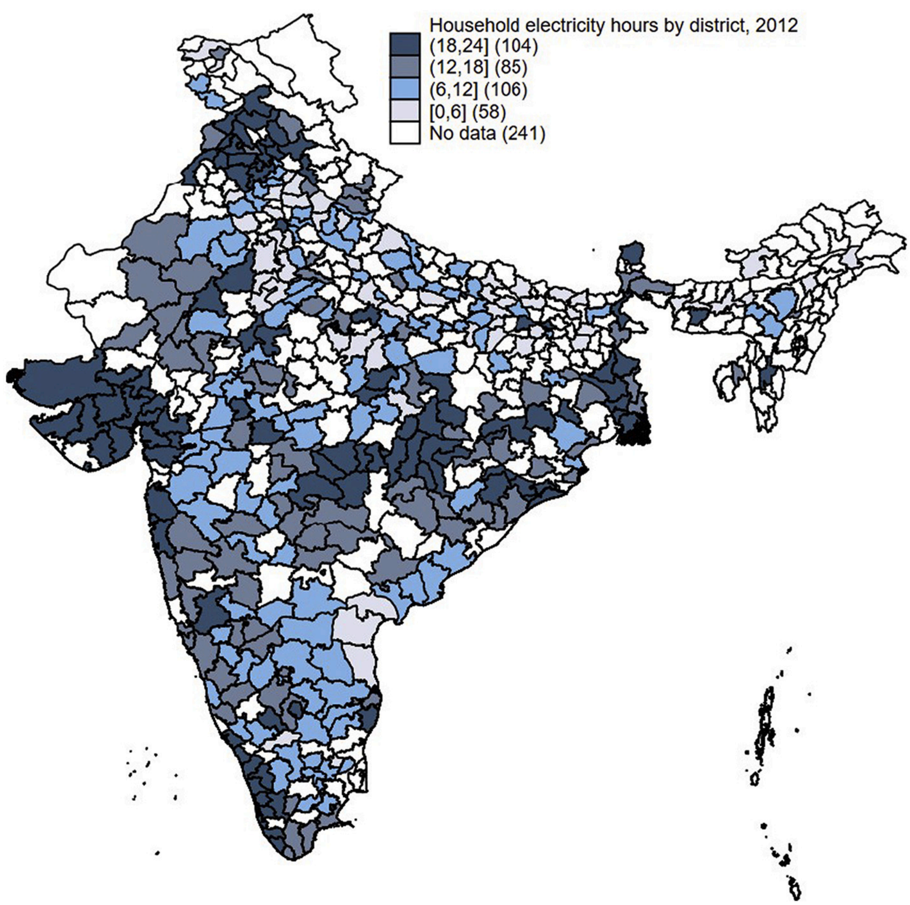

Fig. 2. Hours of electricity available on a typical day in the household at the district level in India, 2012, IHDS.
The data for the map is derived from "https://www.diva-gis.org/gdata". Note-The figure was drawn according to the administrative boundary of India, not the actual boundary.

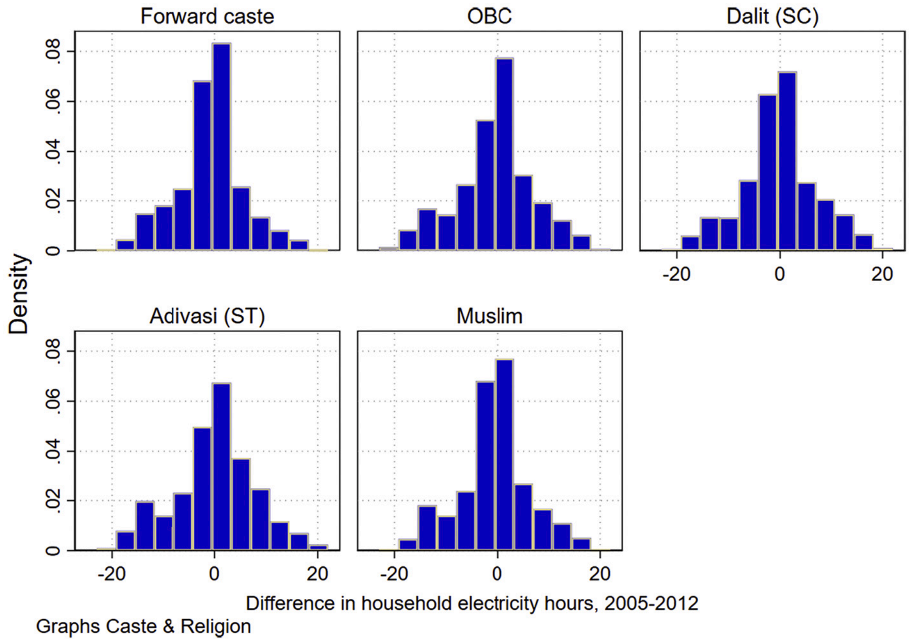

Fig. 3. Difference in the hours of electricity received by households on a typical day by social groups, 2005–2012.

Table 3
OLS, FE and IV-FE: likelihood of electricity access for social groups, IHDS, 2005–2012.

	(1)	(2)	(3)	(4)	(5)
Electricity Access (0/1)					
	OLS	FE	IV-FE	IV-FE	IV-FE
2012	0.118***	0.089***	0.064***	0.089***	0.132***
	(0.002)	(0.003)	(0.005)	(0.005)	(0.009)
Hindu SC/ST	−0.051***				
	(0.003)				
SC/ST v Others Hindu (2012)	0.059***	0.065***	0.067***		
	(0.004)	(0.003)	(0.003)		
Muslims v All Hindu (2012)				0.011***	
				(0.004)	
Muslims v Hindu SC/ST (2012)					−0.040***
					(0.005)
Log annual HH. Cons.	0.137***	0.038***	−0.028***	−0.034***	−0.067***
	(0.002)	(0.002)	(0.009)	(0.009)	(0.019)
Household Head Education	0.015***	0.002***	0.004***	0.003***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Age in years	0.000*	0.001*	0.001	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Household size	−0.016***	0.000	0.006***	0.006***	0.013***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Below Poverty Line Card	0.023***	0.010***	0.007**	0.004	−0.005
	(0.002)	(0.003)	(0.003)	(0.003)	(0.005)
F test (instrument)			8113	9219	4005
Observations	154,824	154,824	154,697	174,992	70,450
Number of Individuals		78,064	78,011	88,131	37,952

Robust standard errors are clustered at the individual level. p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Age is above 18 years for respondents. The instrument is used to capture the non-random correlation between household consumption and electricity access. Following Saxena and Bhattacharya (2018), the instrument used is ownership of motor vehicles which is argued to affect household consumption but not electricity access. The instrument is strong as per the criteria for weak instrument given by Staiger and James (1997), and various other tests for instruments given in the *xtoverid, nois* command in stata.

As expected the individual fixed effects estimates in column 2 reduces the bias by capturing the time invariant unobserved heterogeneity at an individual level, therefore the overall coefficient of absolute change for the forward caste groups are smaller.[26] The fixed effects analysis shows that in relative terms the SC/ST caste groups were 6.5 percentage points more likely than the forward caste groups to get electricity access. In absolute terms, the SC/ST groups had a 15.4 percentage point likelihood of electricity access as compared to 8.9 percentage points of the forward caste.

The fixed effects instrumental variables regression further reduces the bias in estimation by capturing the remaining time varying unobserved heterogeneity. The IV coefficient in column 3 corrects for the positive selection bias between household consumption expenditure and electricity access, therefore the overall coefficient of absolute change for the forward caste groups is even smaller as compared to the coefficient of fixed effects in column 2.[27] The IV point estimate shows that the Hindu SC/ST groups were 6.7 percentage points more likely than the Hindu forward caste groups to get electricity access. In absolute terms the SC/ST groups had a 13.1 percentage point likelihood of electricity access as compared to 6.4 percentage points of the forward caste.

Column 4 shows the likelihood of electricity access for Muslims in the sample of all Hindu and Muslim households. The IV estimate shows that Muslims were 1.1 percentage points more likely to get electricity access as compared to all Hindus. In absolute terms, Muslims had a 10 percentage point likelihood of electricity access as compared to 8.9percentage points of all Hindus. In column 5, the comparison is between the Muslims and the Hindu SC/ST group. Here, we find that the Muslims were less 4 percentage points likely compared to Hindu SC/ST groups to get electricity access. In absolute terms the Muslims had 9.2 percentage point likelihood of electricity access as compared to 13.2 percentage points of the Hindu SC/ST groups. Overall the results in Table 3 shows that the marginalized groups had a higher likelihood of electricity access as compared to dominant groups.

The use of fixed effects instrumental variable regressions in column 3, 4 and 5 corrects not only the positive selection bias of household consumption and electricity access,[28] but also for bias of dominant caste having a higher likelihood of electricity connection as is expected in cross sectional estimations. Using instrumental variable in a fixed effects model captures the program effort of RGGVY to electrify the unelectrified, mostly poor and disadvantaged households, and reduces the dominant group selection into electricity access. In this regard, our results are robust, and add to the previous literature by Saxena and Bhattacharya (2018) who use the cross sectional technique and instrument for the household consumption only (used as a covariate in their study), while disregarding the selection bias of social groups, i.e., the likelihood of electricity access when the individual belongs to a dominant or a marginalized group.

Table 4 looks at electricity access in rural and urban areas derived from the panel IV estimations. Results from this analysis shows that electrification that happened between 2005 and 2012 was more of a rural phenomenon. In rural areas, the Hindu SC/ST groups were 6.8 percentage points more likely to have electricity access as compared to forward caste Hindus, while in urban areas, they were 3.9 percentage points more likely to have electricity access as compared to the forward caste Hindus. In urban areas, there was no significant increase in the likelihood of electricity access for the forward caste. This could be true because of the high base of electricity access in urban areas for forward caste Hindus (97% and 95% access in 2005, and 99% and 97% access in 2012 in urban areas for the forward caste and OBC, respectively), while a relatively lower access for Hindu SC/ST groups and Muslims.

Column 3 shows that in rural areas, Muslims had 4.5 percentage point higher likelihood of electricity access as compared to all Hindus. While in urban areas (column 4), there was no effect of being a Muslim on the likelihood of electricity access compared to the 1.8 percentage point increase in urban areas for all other Hindus. In column 5, we see that being a Muslim had no effect on the likelihood of electricity access when compared to Hindu SC/ST groups in rural areas, while in urban areas (column 6) Muslims had a significantly lower likelihood (3 percentage points) of having electricity access as compared to the Hindu SC/ST groups.

In Table 5, we analyze the reliability of electricity by social groups in a period when, on average, household electricity hours on a typical day decreased at the national level. Results in column 1 of the OLS regression shows that the Hindu SC/ST groups had a lower decrease in electricity hours as compared to Hindu forward caste groups. For the SC/ST groups the decline in electricity hours on a typical day was for 0.70 h, while for the forward caste groups, the decline was 1.32 h on a typical day.

In column 2, the panel fixed effects model shows that the decline for the SC/St groups was 0.73 h, while the decline for the forward caste groups was 1.42 h on a typical day. The IV estimate in column 3 shows that the decline for the SC/ST groups was 0.71 h, while the decline for the forward caste groups was 1.40 h. Column 4 shows that Muslims did have more decline than all other groups, but the magnitude of the effect was small and insignificant. In column 5, when comparing Muslims to Hindu SC/ST groups, we see that the decline in electricity hours was significantly more for the Muslims as compared to Hindu SC/St groups. For Muslims in the sample of Hindu SC/ST groups and Muslims only, the decrease for Muslims was 1.16 h as compared to the decrease of 0.76 h for the Hindu SC/ST groups. Overall, the decrease in electricity hours was highest for the forward caste Hindus, followed by the Muslims, and the least for the Hindu SC/ST groups.

In Table 6, we look at the reliability of electricity by social groups in rural and urban areas derived from the panel IV estimations. For the Hindu SC/ST groups, the decline in electricity hours was 0.75 and 0.53 h in rural and urban areas, respectively. In comparison, the decline in electricity hours for the forward caste Hindus was 1.4 h and 1.24 h in rural and urban areas, respectively. For Muslims in comparison to all Hindu groups, the decline was 0.43 and 0.55 in rural and urban areas, respectively. While the decline for all Hindu groups was 1.37 and 1.22 h in rural and urban areas, respectively. For the sub-sample of Muslims and Hindu SC/ST groups, results show that the Muslims has a much higher reduction in electricity hours in rural areas as compared to the Hindu SC/ST groups. For Muslims, the decline was 1.1 h as compared to 0.82 h for the Hindu SC/ST groups in rural areas. In urban areas there was a higher decline for Muslims as compared to Hindu SC/St groups, but the decline was insignificant.

5.2.2. Electrification at the regional level

In this section, we examine the likelihood and reliability of electrification for the marginalized and other groups using household fixed effects at the regional level (seven regions in India). For this analysis, we club the Hindu SC/ST groups and Muslims as marginal groups for the ease of exposition. This exercise is crucial in understanding the how historical differences at the regional level between marginalized groups and other could affect the likelihood of electrification. A combination of different social reform histories, cultural differences, and several other factors lends states and regions in India a varied background. Moreover, post-independence socio-economic developments seem to have

[26] The fixed effect estimation controls for the individual characteristics which are invariant overtime, such as the caste of the individual. This reduces the coefficient for dominant groups as at any point in time, we expect the dominant groups to have higher electricity access as compared to the marginalized groups. Capturing this individual specific characteristic is what reduces the coefficient when we move from the OLS to the fixed effects model.

[27] Table 1 shows that in general, the forward caste groups have higher consumption levels and therefore, using the IV reduces the positive selection bias of higher consumption level leading to more likelihood of electricity access.

[28] Note, using the IV model changes the coefficient for household consumption expenditure on electricity access from positive to negative, which shows that the program based targeting in RGGVY was towards poorer households who were less likely to be electrified.

Table 4
Panel fixed effects instrumental variables regression: likelihood of electrification in rural and urban areas for social groups, IHDS, 2005–2012.

	(1)	(2)	(3)	(4)	(5)	(6)
Electricity access (0/1)						
	Rural	Urban	Rural	Urban	Rural	Urban
2012	0.097***	0.005	0.125***	0.018***	0.174***	0.041***
	(0.007)	(0.005)	(0.007)	(0.004)	(0.013)	(0.009)
SC/ST v Others Hindu (2012)	0.068***	0.039***				
	(0.004)	(0.004)				
Muslims v All Hindu (2012)			0.045***	0.003		
			(0.007)	(0.004)		
Muslims v SC/ST Hindu (2012)					−0.000	−0.030***
					(0.007)	(0.006)
Log annual HH. Cons.	−0.030**	−0.015*	−0.034**	−0.019***	−0.029	−0.049***
	(0.014)	(0.008)	(0.014)	(0.007)	(0.031)	(0.018)
F test (instrument)	6510	3211	7221	4100	3798	1122
Observations	109,010	45,687	120,140	54,852	49,819	20,631
Number of Individuals	55,608	23,680	61,271	28,322	26,883	11,668

Robust standard errors are clustered at the individual level in parentheses, p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Age is above 18 years for respondents. Following Saxena and Bhattacharya (2018), the instrument used is ownership of motor vehicles which is argued to affect household consumption but not electricity reliability. The instrument variable is used to capture the non-random correlation between household consumption and electricity reliability. The instrument is strong as per the criteria for weak instrument given by Staiger and James (1997), and various other tests for instruments given in the *xtoverid, nois* command in stata.

Table 5
OLS FE and IV-FE: Electricity reliability (hours of electricity available on a typical day) by social groups in India, 2005–2012.

	(1)	(2)	(3)	(4)	(5)
Electricity hours (0–24)					
	OLS	FE	IV-FE	IV-FE	IV-FE
2012	−1.320***	−1.425***	−1.409***	−1.332***	−0.776***
	(0.050)	(0.077)	(0.123)	(0.113)	(0.213)
Hindu SC/ST	−0.065				
	(0.060)				
SC/ST v Others Hindu (2012)	0.616***	0.689***	0.692***		
	(0.084)	(0.065)	(0.065)		
Muslims v All Hindu (2012)				−0.054	
				(0.085)	
Muslims v SC/ST Hindu (2012)					−0.386***
					(0.103)
Log real HH. Cons.	−0.036	−0.170***	−0.118	−0.139**	−0.165***
	(0.035)	(0.045)	(0.245)	(0.230)	(0.473)
Household head education	0.208***	−0.010	−0.013	0.003	0.004
	(0.005)	(0.009)	(0.010)	(0.010)	(0.016)
Age in years	0.007***	0.056***	0.056***	0.049***	0.039***
	(0.001)	(0.009)	(0.009)	(0.008)	(0.014)
Household Size	−0.308***	−0.016	−0.020	0.032	0.228***
	(0.007)	(0.011)	(0.023)	(0.021)	(0.043)
Below Poverty Line Card	−0.673***	0.087	0.089	0.061	0.095
	(0.044)	(0.061)	(0.062)	(0.058)	(0.097)
Constant	16.481***	16.178***	15.600***	20.993***	38.264***
	(0.399)	(0.629)	(2.825)	(2.655)	(5.417)
F test (instrument)			9658	10,113	4201
Observations	116,909	116,909	116,805	131,777	43,896
Number of individuals		58,545	58,545	66,056	22,014

Robust standard errors are clustered at the village level in parentheses, p-values—***$p < 0.01$, **$p < 0.05$. *$p < 0.1$. Analysis of electricity hours is conditional on electricity access. Age is above 18 years for respondents. The instrument is used to capture the non-random correlation between household consumption and electricity access. Following Saxena and Bhattacharya (2018), the instrument used is ownership of motor vehicles which is argued to affect household consumption but not electricity access. The instrument is strong as per the criteria for weak instrument given by Staiger and James (1997), and various other tests for instruments given in the *xtoverid, nois* command in stata.

sustained the pattern of regional variation rather than diminished it (Deshpande, 2001). As Burlig and Preonas (2016) show that the RGGVY program had a fairly wide distribution in terms of the program implementation during the 10th and the 11th five year plans combined, 2002–2012 (see Fig. 1, pp. 45), ceteris paribus, we anticpate the regional effects across the social groups to be the same. However, socio-economic differences among the marginalized and other groups at the regional level could be an important factor in determining the effectiveness of the electrification drive in electrifying households. Understanding this regional variation in electrification is important not only to acquire a sense of how different historical processes work, but also to design electrification policies better suited to regional needs.

Table 7 shows the likelihood and reliability of electrification at the household level by regions in India. Panel (a) shows the likelihood of electrification. In the Hills (Jammu and Kashmir, Himachal Pradesh and

Table 6
Panel fixed effects instrumental variables regression: electricity reliability (hours of electricity in a typical day) in rural and urban areas for social groups, IHDS, 2005–2012.

Electricity Hours (0–24)	(1) Rural	(2) Urban	(3) Rural	(4) Urban	(5) Rural	(6) Urban
2012	−1.400***	−1.248***	−1.376***	−1.226***	−0.822***	−0.641***
	(0.164)	(0.199)	(0.155)	(0.174)	(0.166)	(0.195)
Hindu SC/ST v Other Hindu (2012)	0.654***	0.719***				
	(0.083)	(0.108)				
Muslims v All Hindu (2012)			−0.941***	0.671***		
			(0.134)	(0.114)		
Muslims v SC/ST Hindu (2012)					−0.278***	−0.213
					(0.153)	(0.168)
Log real HH. Cons.	0.081	−0.280	−0.482	−0.672*	−0.603***	−0.925***
	(0.323)	(0.394)	(0.311)	(0.356)	(0.298)	(0.268)
F test (instrument)	6701	4552	7093	4671	3239	1998
Observations	74,262	42,543	80,747	51,030	27,312	16,584
Number of individuals	37,754	21,875	41,104	26,217	13,947	8547

Robust standard errors are clustered at the individual level in parentheses, p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Age is above 18 years for respondents. Electricity reliability is conditional on electricity access. Following Saxena and Bhattacharya (2018), the instrument used is ownership of motor vehicles which is argued to affect household consumption but not electricity reliability. The instrument variable is used to capture the non-random correlation between household consumption and electricity reliability. The instrument is strong as per the criteria for weak instrument given by Staiger and James (1997), and various other tests for instruments given in the *xtoverid, nois* command in stata.

Table 7
Panel fixed effects instrumental variable regressions: Differences in electricity access and reliability between marginalized households and all other households by region, India, 2005–2012.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Electricity Access (0/1)						
	Hills	North	North Central	Central Plains	East	West	South
Panel (a)							
2012	0.006	0.005	0.211***	0.132***	0.124***	0.027***	0.007
	(0.009)	(0.007)	(0.019)	(0.014)	(0.013)	(0.010)	(0.008)
SC/ST/Muslims*2012	0.024***	0.017***	0.035***	0.036***	0.085***	0.065***	0.052***
	(0.006)	(0.005)	(0.010)	(0.008)	(0.008)	(0.007)	(0.005)
Log real HH. Cons.	−0.063***	−0.017	0.201***	0.040	−0.021	−0.045***	−0.071***
	(0.016)	(0.011)	(0.039)	(0.029)	(0.024)	(0.016)	(0.016)
F test (instrument)	139	264	289	399	491	654	424
Observations	12,478	15,311	26,138	30,206	26,804	25,314	38,741
Number of Individuals	6281	7739	13,164	15,184	13,489	12,741	19,533
Electricity Hours (0–24)							
Panel (b)							
2012	−1.955***	0.388	0.083	1.467***	−3.789***	−1.141***	−3.784***
	(0.337)	(0.357)	(0.349)	(0.230)	(0.312)	(0.300)	(0.248)
SC/ST/Muslims*2012	−0.581***	1.361***	1.143***	−0.545***	1.061***	0.988***	0.837***
	(0.140)	(0.203)	(0.156)	(0.119)	(0.165)	(0.153)	(0.127)
Log real HH. Cons.	−1.521**	0.976	−0.609	0.225	−1.849***	−0.583	−0.962*
	(0.651)	(0.773)	(0.609)	(0.486)	(0.563)	(0.494)	(0.562)
F test (instrument)	146	254	207	318	385	618	408
Observations	11,821	14,445	12,486	20,858	15,995	21,794	34,378
Number of individuals	5934	7257	6247	10,445	8016	10,925	17,232

Robust standard errors (clustered at the individual level) in parentheses, p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Results in panel (b) are conditional on electricity access. Additional independent variables in all regressions. States according to regions– Hills: Jammu & Kashmir, Himachal Pradesh, Uttarakhand, North: Punjab, Haryana, Chandigarh, Delhi, North Central: Uttar Pradesh, Bihar, Jharkhand, Central Plains: Rajasthan, Chattisgarh, Madhya Pradesh, East: Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Assam, West Bengal, Odisha, West: Gujarat, Daman and Diu, Dadra and Nagar Haveli, Maharashtra, Goa, South: Andhra Pradesh, Karnataka, Kerela, Tamil Nadu, Pondicherry. Note some of the states mentioned are Union Territories, the classification is following IHDS (2005–2012). Following Saxena and Bhattacharya (2018), the instrument used is ownership of motor vehicles which is argued to affect household consumption but not electricity reliability. The instrument is strong as per the criteria for weak instrument given by Staiger and James (1997), and various other tests for instruments given in the *xtoverid, nois* command in stata.

Uttarakhand), marginalized groups registered a positive increase in the likelihood of electrification (2.4 pp)[29] as compared to other groups, who did not register any significant increase in the likelihood of electrification. The same applies to regions in the North (Punjab, Haryana, Chandigarh and Delhi). In the North Central regions (Uttar Pradesh, Bihar and Jharkhand), marginalized groups realized a higher increase in electricity access (24 pp) as compared to other groups (21 pp). Similarly, in the Central Plains (Rajasthan, Chattisgarh and Madhya Pradesh) marginalized groups realized a higher increase in electricity

[29] Note: pp. is percentage points.

access (16.8 pp) as compared to other groups (13.2 pp). Similarly in the East (Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Assam, West Bengal and Odisha), marginalized groups realized a higher increase in electricity access (20.9 pp) as compared to other groups. In the West (Gujarat, Daman and Diu, Dadra and Nagar Haveli, Maharashtra and Goa), marginalized groups realized a higher increase in electricity access (9.2 pp) as compared to others (2.7 pp). Also, in the South (Andhra Pradesh, Karnataka, Kerela, Tamil Nadu and Pondicherry), marginalized groups realized a positive and significant increase in electricity access (5.2 pp) as compared to no increase for the other groups. In terms of electricity reliability, panel (b) in Table 7 shows that the marginalized groups saw a higher decline in the Hills and in the Central Plains. While in all other regions, marginalized groups saw a significantly lower reduction in electricity hours as compared to other groups. Looking the dynamics of regional variation in household electrification, we can say that there are regional variations in household access and reliability of electrification. Some regions such as the East and the West did better than other regions in terms of electricity access and reliability for the marginalized groups as compared to other groups. While some regions, such as the Hills and the Central Plains had worse outcomes in terms of electricity reliability of the marginalized groups as compared to other groups.

5.3. *Electrification as a means*

As argued by Burlig and Preonas (2016), electricity is critical for household welfare. In this regard, this section examines the effect of electricity access and reliability on household welfare in terms of assets, consumption and status of poverty. The analysis shows how the gains in electricity access and reliability were utilized by social groups for welfare gains. Given the socio-economic constraints faced by marginalized groups (Thorat and Neuman, 2012), the analysis reflects on whether the access to basic infrastructures such as electricity allows households to derive benefits of it regardless of their social organization.

Table 8 shows the effect of electricity access and reliability on household assets in general. Here the assets are a cumulative of 30 dummy variables that relate to both electrical and non-electrical appliances along with ownership of the house. Panel (a) shows the effect of electricity access and panel (b) shows the effect of electricity reliability on assets for the forward caste Hindus, SC/ST Hindus and Muslims separately.

Column 1 and 2 in panel (a) show that electricity access led to 2 more assets for the forward caste groups in rural areas and 3.3 more assets in urban areas. For the SC/ST groups, column 3 and 4 in panel (a) show that electricity access led to 1.8 and 2.9 more assets in rural and urban areas, respectively. For Muslims, column 5 and 6 show that electricity access led to 2.4 and 2.9 more assets in rural and urban areas, respectively. Results from panel (a) shows that all the social groups benefited from electricity access, but the dominant groups benefited relatively more than the marginalized groups. Results in panel (b) show the effects of electricity reliability on assets for the social groups. Here again, the forward caste Hindus benefited from electricity reliability both in rural and urban areas, while more electricity hours had a significant effect only in rural areas for the Hindu SC/ST groups. For Muslims, increased electricity hours had no significant effect on asset ownership.

In Table 9, we examine the effect of electricity access on household annual consumption expenditure. Panel (a) shows the results for the effects of electricity access on log of annual household consumption expenditure while panel (b) shows the effect of electricity reliability.

Column 1 and 2 in Table 9 shows that electricity access increase the annual consumption expenditure of Hindu forward caste households by 13.4 and 12% in rural and and urban areas, respectively. Column 4 and 5 shows that electricity access increased consumption expenditure of Hindu SC/ST households by 8.7% in rural areas, while in urban areas there was negligible and insignificant effect of electricity access on consumption expenditure. For Muslims, column 5 and 6 shows that electricity access increased their consumption expenditure by 11.8 and 6.2% in rural and urban areas, respectively. Overall, the analysis of electricity access and consumption expenditure shows that the marginalized groups benefited less from electricity access as compared to dominant groups in terms of consumption expenditure.

In panel (b) of Table 9, we examine the effect of electricity reliability on consumption expenditure. Here the effect on Hindu SC/ST groups is such that a 10 h increase in electricity hours on a typical day increased

Table 8
Panel fixed effects: Electrification and household assets by social groups in India, 2005–2012.

	(1)	(2)	(3)	(4)	(5)	(6)
Assets (0–30), IHDS, 2005–2012						
	Forward caste Hindus		SC/ST Hindus		Muslims	
	Rural	Urban	Rural	Urban	Rural	Urban
Panel (a) Electricity Access (0/1)	2.099***	3.399***	1.896***	2.923***	2.471***	2.972***
	(0.050)	(0.150)	(0.053)	(0.182)	(0.103)	(0.200)
Log real HH. income	0.538***	0.690***	0.678***	0.810***	0.555***	0.710***
	(0.019)	(0.028)	(0.027)	(0.069)	(0.050)	(0.058)
Wave dummy	3.195***	2.801***	3.008***	2.835***	3.022***	2.824***
	(0.045)	(0.066)	(0.057)	(0.131)	(0.105)	(0.109)
Observations	68,854	34,030	38,344	11,426	10,994	9111
R-squared	0.503	0.442	0.509	0.495	0.526	0.477
Number of individuals	37,100	18,581	21,175	7015	5811	4795
Panel (b) Electricity hours (0–24)	0.012***	0.014***	0.016***	0.009	0.007	0.012
	(0.003)	(0.004)	(0.004)	(0.008)	(0.009)	(0.008)
Log real HH. income	0.542***	0.694***	0.765***	0.808***	0.652***	0.730***
	(0.022)	(0.029)	(0.036)	(0.073)	(0.064)	(0.059)
Wave dummy	3.474***	2.835***	3.589***	2.810***	3.444***	2.822***
	(0.054)	(0.067)	(0.077)	(0.142)	(0.162)	(0.113)
Observations	50,418	32,442	22,577	9880	6299	8287
R-squared	0.494	0.422	0.501	0.455	0.491	0.445
Number of individuals	27,006	17,592	12,507	6019	3341	4335

Robust standard errors (clustered at the individual level) in parentheses, p-values—*** $p < 0.01$, ** $p < 0.05$,
* $p < 0.1$. Results in panel (b) are conditional on electricity access. Additional independent variables in all regressions: household head education, age, below poverty line card (0/1), household size.

Table 9
Panel fixed effects: electrification and annual household consumption expenditure by social groups in India,2005–2012.

	(1)	(2)	(3)	(4)	(5)	(6)
Log of annual household consumption expenditure, IHDS, 2005–2012						
	Forward caste Hindus		SC/ST Hindus		Muslims	
	Rural	Urban	Rural	Urban	Rural	Urban
Panel (a) Electricity access (0/1)	0.134***	0.120***	0.087***	0.005	0.118***	0.062**
	(0.009)	(0.028)	(0.01)	(0.027)	(0.018)	(0.029)
Log real HH. income	0.110***	0.199***	0.105***	0.186***	0.093***	0.166***
	(0.004)	(0.006)	(0.005)	(0.012)	(0.008)	(0.01)
Wave dummy	−0.381***	−0.325***	−0.358***	−0.275***	−0.362***	−0.271***
	(0.009)	(0.013)	(0.01)	(0.019)	(0.018)	(0.019)
Observations	68,839	33,990	38,330	11,426	10,992	9112
R-squared	0.433	0.382	0.443	0.39	0.451	0.392
Number of individuals	37,098	18,581	21,173	7015	5811	4795
Panel (b) Electricity hours (0–24)	0.002**	0.001	0.002**	0.003*	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log real HH. income	0.115***	0.200***	0.115***	0.191***	0.103***	0.163***
	(0.004)	(0.007)	(0.007)	(0.013)	(0.01)	(0.01)
Wave dummy	−0.389***	−0.326***	−0.364***	−0.279***	−0.379***	−0.278***
	(0.01)	(0.014)	(0.013)	(0.021)	(0.026)	(0.021)
Observations	50,407	32,402	22,563	9882	6299	8288
R-squared	0.435	0.379	0.458	0.39	0.446	0.392
Number of individuals	27,007	17,592	12,505	6019	3341	4335

Robust standard errors (clustered at the individual level) in parentheses, p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Results in panel (b) are conditional on electricity access. Additional independent variables in all regressions: household head education, age, below poverty line card (0/1), household size.

their annual consumption expenditure by 2 and 3% in rural and urban areas, respectively. The effect on consumption for the Hindu forward caste is similar at 2% in rural areas, but is marginally lower and insignificant in urban areas. For Muslims, the magnitude of effect of electricity hours is similar to other groups, 2 and 2% in rural and urban areas, respectively, but the coefficients are insignificant. Overall, the analysis of electricity access and reliability shows that marginalized households tend to have similar benefits as dominant groups with electricity reliability, but the same is not true for electricity access.

Further, we examine the effect of electricity access and reliability on the likelihood of transitioning out of poverty for all social groups. In panel (a), we show the effects of electricity access on the likelihood of moving out of poverty and in panel (b) we show the effects of electricity reliability on the same dependent variable.

Column 1 and 2 in panel (a) show that the likelihood of moving out of poverty for the forward caste Hindus was 8.4 and 5.8 percentage points in rural and urban areas, respectively. For the SC/ST households, the effect was similar in rural and urban areas with the likelihood of moving out of poverty being 6.3 percentage points in both rural and urban areas. For Muslims, electricity access reduces the likelihood of being poor by 10.5 and 14.4 percentage points in rural and urban areas, respectively. Overall, poverty reduction through electricity access is the strongest for the Muslims groups, followed by forward caste in rural areas. In panel (b), we examine the effects of electricity reliability on status of poverty. The analysis shows that increasing electricity hours reduces the likelihood of being poor mostly for the forward caste groups. For Hindu the SC/ST groups and Muslims, increasing household electricity hours has no significant effect on poverty reduction.

6. Robustness checks

We carry out two robustness checks (i) effect of electricity access on OECD per capita equivalent annual consumption expenditure, (ii) likelihood of electricity access by social groups using alternative data set: the panel of the Access to Clean Cooking and Energy Services (ACCESS, 2015–2018) survey. The first robustness check is for the analysis of electrification as a means to welfare and the second robustness check is for the analysis of electrification as an outcome.

For the first analysis, we create the OECD equivalent per capita annual consumption variable, calculated as: OECD = 1+ 0.7*(Number of Adults-1) + 0.5*(Number of Children). The OECD equivalent variable gives higher weight to adult consumption, in effect showing a more realistic consumption expenditure figure based on household's adult and children composition. In panel (a) of Table 11, we examine th effect of electricity access on the OECD equivalent consumption. In panel (b), we examine the effect of electricity reliability on the consumption variable.

Column 1 and 2 in panel (a) shows that the forward caste Hindus had a 12.7 and 12.9 percentage point increase in per capita adult equivalent consumption expenditure in rural and urban areas, respectively. Column 3 and 4 show that the Hindu SC/St groups had a 9 percentage point increase in the consumption expenditure in rural areas and no effect in urban areas. Adult consumption expenditure increased significantly for Muslims only in rural areas (12.5 percentage points), while in urban areas the coefficient was positive but insignificant. Results from panel (a) match the results derived on electricity access and consumption expenditure in Table 9 with regards to the relative effects of electricity access on consumption expenditure for the social groups. The only exception is for the Muslim groups consumption expenditure, which was positive and significant at the household level, but was positive but insignificant at the adult per capita level (Table 10).

Panel (b) of Table 11 shows the effect of electricity reliability. Here again, similar to results in panel (b) of 9, electricity reliability had similar effects on the adult equivalent consumption expenditure of Hindu forward caste and SC/ST groups. The exception here again was Muslim groups who had a positive and significant effect of electricity reliability (10 h increase in electricity availability leading to 3 pp. increase in adult equivalent consumption expenditure).

While in 9, there was a positive but insignificant effect of electricity relaibility on household consumption expenditure.

As a second robustness check, we examine the panel of the ACCESS survey and see if the marginalized groups had a higher likelihood of electricity access compared to the dominant groups as shown by our analysis in Table 3, using the same set of independent variables. Pelz

Table 10
Panel fixed effects: electrification and the status of poverty (0/1) for households at the national level, 2005–2012.

	(1)	(2)	(3)	(4)	(5)	(6)
Status of Poverty(0/1)), IHDS, 2005–2012						
	Forward caste Hindus		SC/ST Hindus		Muslims	
	Rural	Urban	Rural	Urban	Rural	Urban
Panel (a)						
Electricity access (0/1)	−0.084***	−0.058**	−0.063***	−0.063**	−0.105***	−0.144***
	(0.008)	(0.027)	(0.01)	(0.032)	(0.018)	(0.035)
Log real HH. income	−0.033***	−0.053***	−0.042***	−0.052***	−0.045***	−0.087***
	(0.002)	(0.003)	(0.005)	(0.009)	(0.006)	(0.008)
Wave dummy	0.007	−0.063***	0.002	−0.133***	−0.016	−0.160***
	(0.006)	(0.008)	(0.01)	(0.019)	(0.015)	(0.018)
Observations	68,839	33,990	38,330	11,426	10,992	9112
R-squared	0.05	0.083	0.046	0.1	0.049	0.152
Number of individuals	37,098	18,581	21,173	7015	5811	4795
Panel (b)						
Electricity hours (0–24)	−0.002***	−0.002***	0	−0.002	−0.001	−0.002
	0	0	(0.001)	(0.001)	(0.001)	(0.001)
Log real HH. income	−0.024***	−0.051***	−0.043***	−0.052***	−0.042***	−0.083***
	(0.002)	(0.003)	(0.005)	(0.009)	(0.005)	(0.008)
Wave dummy	0.001	−0.061***	0.008	−0.122***	−0.005	−0.140***
	(0.006)	(0.008)	(0.012)	(0.019)	(0.017)	(0.019)
Observations	50,407	32,402	22,563	9882	6299	8288
R-squared	0.032	0.081	0.039	0.096	0.037	0.136
Number of individuals	27,007	17,592	12,505	6019	3341	4335

Robust standard errors (clustered at the individual level) in parentheses, p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Results on electricity hours are conditional on electricity access. Additional independent regressors include household head's education, household size and age of the respondent. The cut-off point for considering a household being poor is derived from the Tendulkar cut-off line (2012) (Desai and Vanneman, 2018).

Table 11
Panel fixed effects: electrification and OECD annual per capita equivalent expen- diture by social groups, IHDS, 2005–2012.

	(1)	(2)	(3)	(4)	(5)(	(6)
Log OECD per capita annual expenditure, IHDS, 2005–2012						
	Forward caste Hindus		SC/ST Hindus		Muslims	
	Rural	Urban	Rural	Urban	Rural	Urban
Electricity access (0/1)	0.127***	0.129***	0.090***	0.009	0.125***	0.036
	(0.009)	(0.03)	(0.01)	(0.03)	(0.02)	(0.031)
Log real HH. income	0.108***	0.188***	0.107***	0.179***	0.093***	0.164***
	(0.004)	(0.007)	(0.005)	(0.013)	(0.009)	(0.01)
Wave dummy	−0.366***	−0.339***	−0.350***	−0.301***	−0.362***	−0.285***
	(0.009)	(0.014)	(0.011)	(0.021)	(0.019)	(0.02)
Observations	68,839	33,990	38,330	11,426	10,992	9112
R-squared	0.267	0.282	0.273	0.278	0.282	0.293
Number of individuals	37,098	18,581	21,173	7015	5811	4795
Panel (b)						
Electricity hours (0–24)	0.002***	0.001	0.002***	0.002	0.001	0.003**
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Log real HH. income	0.113***	0.188***	0.116***	0.184***	0.102***	0.160***
	(0.004)	(0.007)	(0.007)	(0.014)	(0.011)	(0.011)
Wave dummy	−0.377***	−0.340***	−0.348***	−0.312***	−0.396***	−0.293***
	(0.011)	(0.015)	(0.015)	(0.023)	(0.027)	(0.021)
Observations	50,407	32,402	22,563	9882	6299	8288
R-squared	0.279	0.281	0.285	0.278	0.326	0.298
Number of individuals	27,007	17,592	12,505	6019	3341	4335

Robust standard errors (clustered at the individual level) in parentheses, p-values—***$p < 0.01$, **$p < 0.05$,
$p < 0.1$. OECD per capita equivalent consumption expenditure is calculated as: OECD = 1+ 0.7(Number of Adults-1) + 0.5*(Number of Children). Analysis of electricity reliability is conditional on electricity access.

et al. (2020) had conducted a similar analysis using the same panel of the ACCESS survey, albeit without an instrumental variable analysis. They found that the marginalized groups (SC/ST groups)[30] were not more likely than forward caste groups in getting electricity access.

The panel fixed effects analysis in column 2 of Table 12 gives similar results to the analysis by Pelz et al. (2020) in that the marginalized groups were no more likely than the forward caste groups in receiving electricity access. Their study shows that both caste groups had 17.8 pp. likelihood of getting electrified between 2015 and 2018, while our analysis shows the likelihood to be 16.5 pp. The difference could be because they take an unbalanced sample and we use a balanced sample analysis. Also, they use household consumption expenditure, household size and having a BPL card as control, while we add additional controls such as household head's education and age in years of the respondent.

[30] In the ACCESS survey, Muslims are not a separate group and are accounted within the caste system).

Table 12
OLS, FE and IV-FE: likelihood of electricity access for social groups, ACCESS, 2015–2018.

Electricity Access (0/1)	(1)	(2)	(3)
	OLS	FE	IV-FE
2018	0.168***	0.165***	0.137***
	(0.008)	(0.007)	(0.017)
SC/ST	−0.012		
	(0.011)		
SC/ST*2018	0.016	0.013	0.024*
	(0.014)	(0.012)	(0.013)
Log of HH. Cons. Exp.	0.099***	0.041***	0.013
	(0.006)	(0.007)	(0.068)
HH head education	0.041***	0.020***	0.002
	(0.003)	(0.005)	(0.006)
Age in years	0.001***	0.001	0.001*
	(0.000)	(0.000)	(0.000)
Household Size	0.004***	0.003**	0.016***
	(0.001)	(0.002)	(0.004)
Below Poverty Line card	0.018***	−0.001	0.007*
	(0.007)	(0.009)	(0.010)
F (test) instrument			231
Observations	16,939	16,939	16,939
Number of Households		8563	8563

Age is above 18 years for respondents. All households are rural households in the ACCESS data. Hindus and Muslims are classified according to their caste. Status of poverty is measured as yes if the household has a Below Poverty Line card. Column 3 show the results for the instrumental variable regression. The instrument is used to capture the non-random correlation between household consumption and electricity access. Following Saxena and Bhattacharya (2018), the instrument used is ownership of motor vehicles which is argued to affect household consumption but not electricity access. The instrument is strong as per the criteria for weak instrument given by (Staiger and James, 1997), and all other checks for the instruments using the *xtoverid, nois* command in Stata. ACCESS survey states are: Uttar Pradesh, Madhya Pradesh, Bihar,Orissa, Jharkhand and West Bengal.

Pelz et al. (2020) do not conduct an instrumental variable analysis, however, our study motivated by the endogeneity between consumption expenditure and electricity access has a instrumental variable analysis in column 3. The panel fixed effects instrumental variable analysis in 12 shows that the marginalized groups had a higher likelihood of electricity access as compared to the forward caste groups, which is also seen in Table 3. Given that the focus of the DDUGJY program was to electrify the remaining unelectrified households which were presumably poor and from marginalized groups, capturing the potential positive selection bias between higher consumption expenditure and better electricity access led to a significant positive effect. Overall, the two robustness checks show that our results holds for both electricity as a means, and as an outcome analysis when we use alternate dependent variables and alternative data-set.

7. Conclusion and policy implication

7.1. Conclusion

Underscoring the socio-economic inequalities between the marginalized and dominant groups in accessing and utilizing basic infrastructures in India, we analyze the likelihood and reliability of electricity for these groups, during a time period when massive strides were made to electrify the unelectrified households, especially in rural areas. Before the universal electrification program, marginalized communities were less likely to have electricity connection as compared to dominant groups, therefore we anticipated that the RGGVY (program for universal electrification) would have disproportionately increased marginalized community's electricity access. However, existing national level instrumental variables based cross– sectional analysis, and regional panel studies with unbalanced observations across survey waves indicate otherwise, and show that the marginalized communities had comparatively lower or at best similar increases in electricity connection compared to the dominant groups. In the light of these counter-intuitive results, we conduct a robust and causal analysis using the panel of the national level IHDS survey, 2005–2012 to examine household level electrification across social groups in India. Correcting for the issues of endogeneity and simultaneity, we find that the marginalized communities benefited more in terms of electricity access, in line with our hypothesis.

The study addresses three gaps in the existing literature: (i) lack of a national study on electricity access for marginalized communities, in comparison to the dominant groups, (ii) lack of a study on the differences in the intensive margin of electricity reliability (hours of electricity available on a typical day) for the marginalized and dominant groups, and (iii) examination of the utilization of electrification (access and reliability) for welfare gains for the marginalized and dominant group. The study covers a comprehensive time period of electricity reforms since the RGGVY, 2005–2012. We use OLS, FE and IV-FE techniques to arrive at both correlational and causal estimates, in terms of likelihood and utilization of electrification. To capture the endogeneity between electricity (access and reliability) and household consumption we use the instrument: ownership of motor vehicles, which is argued to affect household consumption expenditure, but not electricity access and reliability. This instrument has been empirically proven to be strong by Saxena and Bhattacharya (2018), conducting a similar but cross-sectional analysis.

The major findings of our paper relate to the higher predicted probabilities of accessing electricity connection by the households belonging to the marginalized social groups viz. the Hindu scheduled caste, scheduled tribe and the Muslims. Controlling for the overestimation bias in the OLS and FE models, the IV-FE model shows that the Hindu SC/ST were 6.7 percentage point more likely to get electricity access at the national level between 2005 and 2012. Between 2015 and 2012, when national level household electricity hours dropped on average, the drop for SC/ST groups was relatively lower as compared to the forward caste groups. Looking at the likelihood and reliability of electricity at the regional level between 2005 and 2012, results show that there were huge variations in electricity access and reliability—-while the Eastern regions did better both in terms of electricity access and reliability for the marginalized groups, the Hills and Central Plains fared poorly. Expectedly, results show that the increase in likelihood of electrification for all social groups was higher in rural areas as compared to urban areas.

In terms of utilization of electricity for welfare gains, our study is the first to analyze if the marginalized households were able to translate electricity access into welfare gains in terms of consumption, wealth and status of poverty. Also, we compare the utilization of electricity by marginalized groups with the dominant groups. Results show that the marginalized groups were able to utilize electricity access to increase their consumption levels, assets and also to transition out of poverty. However, in all the household welfare related measures we analyze, the effect of electricity access and reliability was smaller for the marginalized groups as compared to the forward caste groups, indicating that there were other forms of restrictions to household welfare even when electrification was no longer a barrier.

7.2. Policy implications

We frame the discussion of our results using distributional and procedural aspects of the scholarship on energy poverty for marginalized groups. Our results on the differences in electricity access and reliability across the surveys illustrates the need for national analysis, as electricity reforms in India have been a central government prerogative. Any results derived from cross sectional estimations or regional/state level analysis may be confounded by political motivations at the state level, for instance, electoral gains, as argued by Baskaran et al. (2015). Based on our results, we argue that political economic motivations and program implementations play a major role in how marginalized groups fare in terms of electricity access, and socio-economic and political conditions dictate how much benefits the marginalized groups can acquire from the utilization for welfare gains. Also, our analysis of both the extensive and intensive margins of electrification argues for moving beyond counting electrified households as the policy objective, and moving towards ensuring adequate electricity supply becoming accessible to all sections of the population.

Causal analysis of longitudinal data is critical when examining the likelihood of electrification from a policy perspective. This is because marginalized groups that have been historically and persistently deprived, would be demonstrated as discriminated against in terms of resources or infrastructures at any point of time. Available cross sectional casual estimations have used IV for economic condition of the household (Saxena and Bhattacharya, 2018; Kennedy et al., 2019), but miss out of the unobserved correlation between the non-economic factors and time invariant factors, such as household's social group that could affect electricity access. Similarly, only a fixed effects study would not able to capture the time varying unobserved heterogeneity at the micro and macro level, these unobserved variations could have a significant impact on the likelihood of electrification for the marginalized groups. For instance, the national employment guarantee program (MNREGA, 2005) could have affected the marginalized groups relatively more than other groups in terms of relative income growth, as the program targeted the poor and the disadvantaged in rural areas. Change in relative income could be a strong determinant of demand for electricity. Also, marginalized groups are relatively confined to traditional or family based occupations, these occupations might be differently affected by economic shocks at the national level, such as the economic crisis of 2008. This unobserved heterogeneity might confound the actual policy impact of electrification for marginalized groups.

Better access to electricity with national level policy efforts, such as the RGGVY and DDUGJY could be argued to be a means to energy equity, however, the hurdles to equitable welfare lies in utilizing those infrastructures for welfare gains. Our study highlights the need for multi-dimensional policies targeting not just energy access, but also employment, health and education. Any sound public policy such as the electrification program may fail to deliver on the objective of equitable welfare if it is not accompanied by other policies with a multi-dimensional approach to tackle other socio-economic inequalities. Our analysis shows that marginalized groups, on average, did benefit more in terms of electricity access and reliability compared to the dominant groups at the national level, but saw lower gains in consumption, assets and economic status through the utilization of electricity. Therefore, a nation–wide policy impetus on electricity, water, transportation, roads, among others could reduce social disparities in access to basic infrastructures, but it does not guarantee equitable welfare. Comprehensive reforms targeting multi-dimensional aspects of socio-economic inequalities are imperative to reduce age old social disparities.

CrediT authorship contribution statem

Ashish Kumar Sedai: Conceptualization, data analysis, Writing – review & editing. **Ray Mille:** Conceptualization, Supervision, Writing – review & editing.

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