

# Community Electrification and Women's Autonomy

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## Background

- India has shown impressive progress in the extensive margin of electricity recently (**Jain et al., 2018; Agrawal et al., 2021; Kennedy et al., 2020**)
- But intensive margin has not improved at the same pace
- Persistent problems: power outages, especially at night; disparity of reliability between rural and urban areas; also between different states in India
- Focus of the literature shifted from the impacts of extensive margin (**Lipscomb et al., 2013; Khandker et al., 2014; Rathi and Vermaak, 2018**) to intensive margin (**Kennedy et al., 2020; Sedai et al., 2021**) of electricity.

# Intensive margin

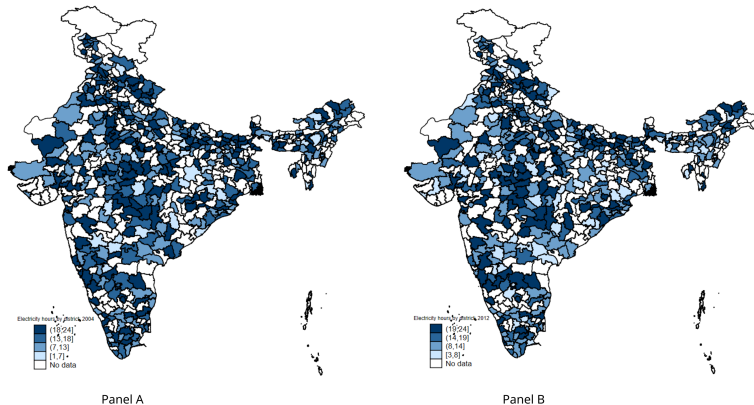


Figure 1: District level average electricity hours in India

## Previous literature vs our contribution

Previous studies	Our paper
Impacts of electrification at household level (Dinkelman, 2011; Winther et al., 2017; Samad and Zhang, 2019; Sedai et al., 2022)	Community level electrification, that incorporates the spill-over effect
No use of administrative data to study the impact on actual crime rate	Impact of reliable community electrification on local crime via enhanced safety in the community
Use of old datasets	Robustness using the recent most datasets
Use of methods like TWFE (that doesn't address the problem of negative weights) and leave-one-out IV (that is questionable in the presence of cross-unit spillover)	Use of the latest DID-M estimator; Results are robust to TWFE and IV method

# Measures of community electrification and women's autonomy

- Two measures of community electrification:
  - Average household electricity hours in a village/town
  - night-time luminosity
- Seven indicators of women's autonomy:
  - Freedom of movement
  - Value of opinion in the household
  - Contraceptive use
  - Receiving treatment in short-term morbidity
  - Mean age of marriage
  - Knowing husband before marriage
  - Violence against women (Number of rapes)

[link](#)

- Indian Human Development Survey (IHDS) panel (2004-05 and 2011-12)
- National Crime Records Bureau (NCRB)
- Socioeconomic High-resolution Rural-Urban Geographic Dataset on India (SHRUG)
- Indian Residential Energy Survey (IRES), 2020
- National Family Health Survey (NFHS), 2019-21

## Empirical strategy

- DID-M estimator proposed by **De Chaisemartin and d'Haultfoeuille (2020)**, which is unique in terms of its flexibility.
- Treatment: Average hours of electricity in a community (distributed continuously over time)
- Assumption: with a movement from period 1 to period 2, treatment of some units changes (movers/switchers) and for the other units, it remains the same (stayers/non-switchers) (**de Chaisemartin et al., 2022**)
- Switchers in: Treatment increases  
Switchers out: Treatment decreases

## Empirical strategy

- DID-M estimator can be described as the weighted average of the following two DID models:
  - DID model that compares the outcome difference of non-switcher groups with the outcome difference of “switchers in” groups.
  - DID model that compares the outcome difference of non-switcher groups with the outcome difference of “switchers out” groups.

$$DID - M = (Y_{s,2012} - Y_{s,2005}) - (Y_{ns,2012} - Y_{ns,2005}) \quad (1)$$



# Results: Impact of community electrification on women's autonomy: DID-M estimator

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Freedom of movement	Value of opinion	Contraceptive use	Treatment received	Mean age of marriage	Knowing husband	Rape
10 hours electricity	0.44*** (0.02)	0.04* (0.02)	0.04*** (0.01)	0.01*** (0.01)	0.07*** (0.02)	0.05*** (0.01)	-0.43* (0.24)
Number of obs	14091	19054	16965	29599	19956	19876	29703
Switchers	6956	9166	8112	14241	9624	9569	14237
Two-stage q values	0.001	0.026	0.001	0.006	0.001	0.001	0.026

Note: Robust standard errors in parentheses (\*\*\*)  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ ). Additional controls included. Source: Authors' calculation.

## Robustness check 1: Falsification tests

	Coefficient (S.E)	No of observations	Switchers
Month of birth dummy	0.000 (0.02)	4403	1833
Month of marriage dummy	0.01 (0.01)	10749	4811
Joint family	0.01 (0.01)	19990	9643

Note: Robust standard errors in parentheses (\*\*\*)  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ ).  
Additional controls included. Source: Authors' calculation.

## Robustness check 2: TWFE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Freedom of movement	Value of opinion	Contraceptive use	Treatment received	Mean age of marriage	Knowing husband	Number of rapes
Panel (a) Linear Estimates							
10 electricity hours	0.33*** (0.04)	0.09*** (0.03)	0.05*** (0.01)	0.03*** (0.01)	0.10** (0.05)	0.06*** (0.01)	-1.40* (0.75)
Panel (b) Piece-wise Linear Estimates							
Baseline electricity (0-11 hours)							
Second tercile (12-19 hours)	0.204*** (0.049)	0.143*** (0.038)	0.061*** (0.015)	0.025*** (0.007)	0.119** (0.061)	0.064*** (0.017)	-0.101 (0.822)
Third tercile (19-24 hours)	0.495*** (0.056)	0.070 (0.043)	0.061*** (0.018)	0.036*** (0.008)	0.121* (0.068)	0.093*** (0.020)	-2.295* (1.201)
Observations	31,441	37,535	35,619	56,077	38134	38,068	62,754
Number of Individuals	19,153	20,346	20,072	30,196	20527	20,520	
Number of Households							34,521

Note: Robust standard errors in parentheses (\*\*\*)  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ ). Individual fixed effects included in col (1) to (6). Household fixed effect included in col (7). Additional controls included. Source: Authors' calculation.

## Robustness check 3: IV

IV: Average electricity hour in the household's district, excluding the PSU where the household lives. Similar IV has been used previously by **Dang and La (2019)**, **Sedai et al. (2021)**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Freedom of movement	Value of opinion	Contraceptive use	Treatment received	Mean age of marriage	Knowing husband	Number of rapes
10 electricity hours	0.54*** (0.05)	0.09** (0.04)	0.05*** (0.02)	0.05*** (0.01)	0.12** (0.05)	0.07*** (0.02)	-2.75*** (0.95)
F test (instrument)	2383.79	2546.08	2332.51	2482.26	2542.76	2523.69	2510.51
Observations	31,043	37,047	35,172	55,356	37636	37,571	62,159
Number of Individuals	18,919	20,102	19,829	29,834	20278	20,271	-
Number of Households	-	-	-	-	-	-	34204
Two-stage q values	0.001	0.008	0.003	0.001	0.009	0.001	0.004

Note: Robust standard errors in parentheses (\*\*\*)  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ ). Individual fixed effects included in col (1) to (6). Household fixed effect included in col (7). Additional controls included. Source: Authors' calculation.

## Robustness check 4: Nightlights as an alternative indicator

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Freedom of movement	Value of opinion	Contraceptive use	Treatment received	Age of marriage	Knew husband	Number of rapes
Log of total light (calibrated)	0.233** (0.095)	0.160** (0.066)	0.085*** (0.030)	0.040*** (0.014)	0.197* (0.101)	0.106*** (0.026)	-4.085** (1.610)
Observations	31,314	37,617	35,619	56,140	38,217	38,153	63,241
Number of Individuals	18,859	19,992	19,755	29,687	20,164	20,156	
Number of Households							34,169
Two-stage q values	0.012	0.011	0.011	0.012	0.018	0.001	0.012

Note: Robust standard errors in parentheses (\*\*\*)  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ ). Individual fixed effects included in col (1) to (6). Household fixed effect included in col (7). Additional controls included. Source: Authors' calculation.

## Robustness check 5: Relevance using recent data

- Most recent energy survey: IRES 2020
- Most recent pan India household survey: NFHS 5 (2019-21)
- We merge these two datasets to show our results are relevant even in the present context

[link](#)

## Robustness check 5: Relevance using recent data

	(1) OLS	(2) IV
<b>(a) Mean age of marriage</b>		
10 electricity hours	1.84* (1.07)	5.63*** (1.74)
F test (instrument)	-	193.75
Observations	3,297	3,297
<b>(b) Freedom of movement</b>		
10 electricity hours	0.19*** (0.07)	0.53*** (0.12)
F test (instrument)	-	876.13
Observations	5,831	5,831
<b>(c) Contraceptive use</b>		
10 electricity hours	0.07*** (0.01)	0.21*** (0.02)
F test (instrument)	-	3282.51
Observations	61,615	61,615
<b>(d) Receiving treatment</b>		
10 hours electricity	0.05*** (0.01)	0.14*** (0.02)
F test (instrument)	-	3282.76
Observations	61,617	61,617
<b>(e) Number of rapes</b>		
10 electricity hours	-11.11*** (2.71)	-37.35*** (4.54)
F test (instrument)	-	2322.99
Observations	53,827	53,827

Note: Robust standard errors in parentheses (\*\*\*)  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ ). Source: Authors' calculation.

## Channels

- **Paid employment:** Electrification increases economic activity and creates more employment opportunities for women.
- **Education:** Reliable community electrification might facilitate opening of evening/night schools and libraries for women and girls who can't attend day schools because of household responsibilities.
- **Awareness/exposure to mass media:** Reliable electricity incentivises households to buy TV or other mass media devices, which will create awareness not only among household members but also among the neighbourhood women.
- **Safety:** If a community is well-lit at night, better safety of women is ensured in that locality, which will allow women to stay out for a longer period at night, for working late or attending night schools.



# Channels

VARIABLES	(1)	(2)	(3)	(4)
	Paid employment of women (0/1)	Years of education of women	Exposure to mass media (TV) (0/1)	Harassment perception
10 hours electricity	0.02*** (0.01)	0.06 (0.05)	0.01* (0.01)	-0.05*** (0.01)
Number of observations	19990	29407	19478	19826
Switchers	9643	14164	9337	9573
Sharpened two-stage q values	0.004	0.079	0.038	0.001

Note: Robust standard errors in parentheses (\*\*\*)  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .  
Additional controls included. Source: Authors' calculation.

Causal Mediation Analysis

## Conclusion

- A comprehensive analysis of how reliable electrification in the community can enhance the social autonomy of women in that community via direct and spillover benefits of electrification.
- The social autonomy indicators we choose for our study are closely linked to existing social and gender norms in India.
- The results help us to understand the norm-breaking ability of reliable electrification in India, which could be useful from policymaking perspective.

*Thank you!*  
*Comments and questions are welcome.*  
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# Women's Autonomy Outcomes: Details

Variable name	Variable description	IHDS 1		IHDS 2		IHDS 1 - IHDS 2
		No of obs	Mean (S.D)	No of obs	Mean (S.D)	t-stat
Freedom of movement	An index constructed by PCA using 3 binary variables: permission to visit health center alone; friend's house alone; and grocery store alone	17,225	-0.070 (0.964)	18,051	0.066 (1.029)	-12.835
Value of opinion	An index constructed by PCA using 3 binary variables: women's participation in household discussion about expenditure, work issues and politics	20,829	-0.023 (1.018)	20,538	0.023 (0.981)	-4.682
Contraceptive use (0/1)	Dummy variable; takes value 1 if the woman uses contraceptive, 0 if no	19,435	0.620 (0.485)	19,520	0.809 (0.393)	-42.110
Short Term Illness Treatment (0/1)	Dummy variable; takes value 1 if the woman receives proper treatment in short-term illnesses	31,293	0.010 (0.3)	31,293	0.178 (0.382)	-28.348
Mean age of marriage	Average of age of marriage of women in a particular community	31,252	17.506 (2.251)	31,255	17.505 (2.164)	0.055
Knowing husband	Dummy variable; takes value 1 if the the woman got to know her husband before marriage, 0 otherwise	21,168	0.325 (0.469)	21,203	0.330 (0.470)	-1.051
Number of rapes	Total number of reported rape cases in the district (winsorized at 1% and 99%) Drawn from the NCRB dataset	35812	36.40 (34.26)	36060	44.20 (36.16)	-29.704

Source: Authors' calculation using IHDS 1, IHDS 2, NCRB 2005 and NCRB 2012.

# Measures of women's autonomy from NFHS

Variables	Variable description	Number of obs	Mean (S.D)
Mean age of marriage	Same as mean age of marriage in IHDS	3,401	15.50 (3.511)
Freedom of movement	An index, created using PCA with two binary variables, permission to visit health center alone and friend's house alone	5,987	0.000 (1)
Contraceptive (0/1)	Same as contraceptive variable in IHDS	63,745	.528 (0.499)
Short Term Illness Treatment (0/1)	Dummy variable; takes value 0 if the woman faced difficulty in receiving treatment in case of illness, 1 otherwise	63,747	.773 (0.419)
Number of rapes	Total number of reported rape cases in the district (winsorized at 1% and 99%) Drawn from the NCRB dataset	53,880	38.303 (37.593)

Source: Authors' calculation using IRES (2020), NFHS 5 (2019-21) and NCRB 2020

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# Causal Mediation Analysis

Three steps:

- 1 To show that the independent variable affects the outcome variables
- 2 To show that the independent variable affects the channel variables/mediators
- 3 To show that the channel variables significantly affect the outcome variables while controlling for the independent variable (if the coefficient of the independent variable is insignificant, then it is the case of complete mediation and if the coefficient is significant, then it is the case of partial mediation)

# Causal Mediation Analysis

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Freedom of movement	Value of opinion	Contraceptive use	Treatment received	Mean age of marriage	Knowing husband
Panel (a)						
Paid employment (0/1)	0.113*** (0.027)	0.015 (0.024)	0.075*** (0.010)	0.012** (0.006)	0.000 (0.025)	0.005 (0.010)
Average electricity hours at PSU	0.034*** (0.004)	0.009*** (0.003)	0.005*** (0.001)	0.003*** (0.001)	0.011** (0.005)	0.006*** (0.001)
Panel (b)						
Years of education	-0.003 (0.006)	-0.005 (0.005)	-0.000 (0.002)	-0.001 (0.001)	0.010* (0.005)	0.005** (0.002)
Average electricity hours at PSU	0.034*** (0.004)	0.009*** (0.003)	0.005*** (0.001)	0.003*** (0.001)	0.011** (0.005)	0.006*** (0.001)
Panel (c)						
Exposure to mass media (0/1)	0.039 (0.029)	0.140*** (0.026)	0.011 (0.010)	0.013** (0.006)	-0.026 (0.026)	0.013 (0.010)
Average electricity hours at PSU	0.033*** (0.004)	0.008*** (0.003)	0.005*** (0.001)	0.003*** (0.001)	0.012** (0.005)	0.005*** (0.001)
Panel (d)						
Harassment perception (0/1)	-0.127*** (0.032)	-0.063** (0.025)	0.008 (0.010)	-0.004 (0.006)	-0.034 (0.032)	-0.034*** (0.011)
Average electricity hours at PSU	0.034*** (0.004)	0.009*** (0.003)	0.005*** (0.001)	0.003*** (0.001)	0.011** (0.005)	0.005*** (0.001)