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RURAL ELECTRIFICATION AND EMPOWERMENT OF WOMEN IN RURAL IRAN

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Rural Electrification and Empowerment of Women in Rural Iran*

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Abstract

We estimate the causal impact of electrification on fertility and the gender gap in education, two important determinants of women's empowerment in rural Iran. An ambitious program of rural electrification started after the 1979 Islamic Revolution extended electricity to rural areas and enabled rural schools and health clinics to operate. Two decades later, despite enforcement of laws and state policies that set the cause of female empowerment back, the gender gap in education had all but disappeared and fertility had dropped by about 5 births per woman. Using a panel of village-level data we show that access to electricity narrowed the gender gap in literacy but increased fertility. The positive effect of electricity on fertility, which runs counter to many empirical findings, is observed when, for better identification, we switch from difference-in-differences to instrumental variable estimation using village elevation from the sea level. We argue that the IV result is plausible because of the complex ways in which electricity affects the costs and benefits of having children. In particular, its negative effect on fertility arising from a higher opportunity cost of children is weak in the case of rural Iran because there women's market work rarely competes with child rearing.

Keywords— Electrification, female empowerment, education, fertility, impact evaluation, Iran
JEL Classification: J14, O12, O18

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1 Motivation

There are multiple ways in which economic development contributes to greater gender equity and female empowerment (Duflo 2012; Jayachandran 2015). One potential channel of influence is investment in infrastructure, which is precondition for economic development (Agénor and Moreno-Dodson (2006), Winther et al. (2017)). There is plenty of evidence that electrification and construction of roads, schools, and health facilities improve general welfare, but much less is known if they also contribute to gender equity by benefiting women more than men. Better infrastructure may cause women's education to rise faster than men, increase women's access to market work, and help them control (and reduce) their fertility.

The relationship between infrastructure and women's empowerment matters because gender equity is an end in itself and because it contributes to economic development. A growing literature studies how electrification can empower women by increasing their access to employment, education, and fertility control. Dinkelman (2011) in South Africa and Grogan (2016) in Nicaragua provide evidence that access to electricity increased women's participation in market work. Khandker et al. (2013) in Vietnam and Khandker et al. (2014) in India find that the impact of electrification is stronger on women's education than men's, and in Bangladesh Fujii and Shonchoy (2020) find that electrification reduces fertility.

There are strong reasons to believe that this impact may differ from country to country. For example, female employment may not respond to electrification where lack of electricity is not the binding constraint on women's working outside the home. This is the case in the oil-rich nations of the Middle East, including Iran, where electricity networks have expanded rapidly, at least in urban areas, but female employment is constrained by Islamic norms and the availability of non-labor income from oil (Ross 2008). Likewise, the gender gap in education could go either way depending on social norms regarding boy vs. girl education. The behavior of fertility after electrification could also be location specific because time spent with children does not always compete with women's market work. In such cases, the positive income from electrification on demand for children may outweigh its negative price effect.

In this paper we present evidence on the impact of electrification on fertility and the gender gap in adult literacy in rural Iran. There are several reasons to be interested in the case of Iran. First, the rapid increase in electrification after the revolution makes for better identification of impact and more precise estimation. As with other popular revolutions, Iran's Islamic revolutionary government embarked on a large scale effort to redress what it considered neglect of the rural areas under the Shah with road construction, electrification and other basic services (Salehi-Isfahani 2020). Second, in rural Iran women's engagement in market work is mostly in home production that does not interfere much with their domestic activities, in particular child rearing. As a result, the impact of electrification on fertility can go either way depending on the relative sizes of the positive income effect and the negative price effect arising from from a higher opportunity cost of children. Theoretically, electricity affects the cost of children in complex ways as it affects the productivity of women in domestic as well as market activities. The net effect may well be negative because in many ways electrification works to reduce fertility, for example by increasing women's education or access to TV (Jensen and Oster 2009).

A third reason to study the impact of electrification on female empowerment in Iran is that it can illuminate a uniquely Iranian puzzle; namely, that despite decades of state policies to restrict women's access to jobs and the public spaces and to define their roles in Islamic Iran as mothers and home makers, the two most important indicators of female empowerment, the gender gap in education and fertility, suggest women's status has improved. Almost immediately after the revolution, the government enforced strict observance of the Islamic dress code (hejab) for women and schools and public spaces were gender segregated (Shahrokni 2019). The Family Protection Act of 1967 that had given women the right to divorce was repealed and replaced with the Islamic (sharia) law. The Shah's family planning program was suspended and was not replaced with its Islamic version until a decade later.

Yet, for the cohort of women who reached school age around the time of the revolution, the gender gap in years of schooling has reversed in urban areas and all but disappeared in rural areas (See Figure 2). Since the mid 2000, women have outnumbered men in universities and their fertility has dropped to replacement level. Rural fertility, which had proved resistant to family planning policies under the Shah (Aghajanian 1995; Abbasi-Shavazi, McDonald, and Hosseini-Chavoshi 2009), dropped from 8 births per woman to 2 in a span of 15 years (Fig 1), setting a world record according to the *Economist*(2009) magazine. We believe that estimating the impact of rapid construction of rural infrastructure after the revolution, especially electrification, on women can provide important insight into this Iranian puzzle.

Figure 1: Fertility decline in rural and urban areas

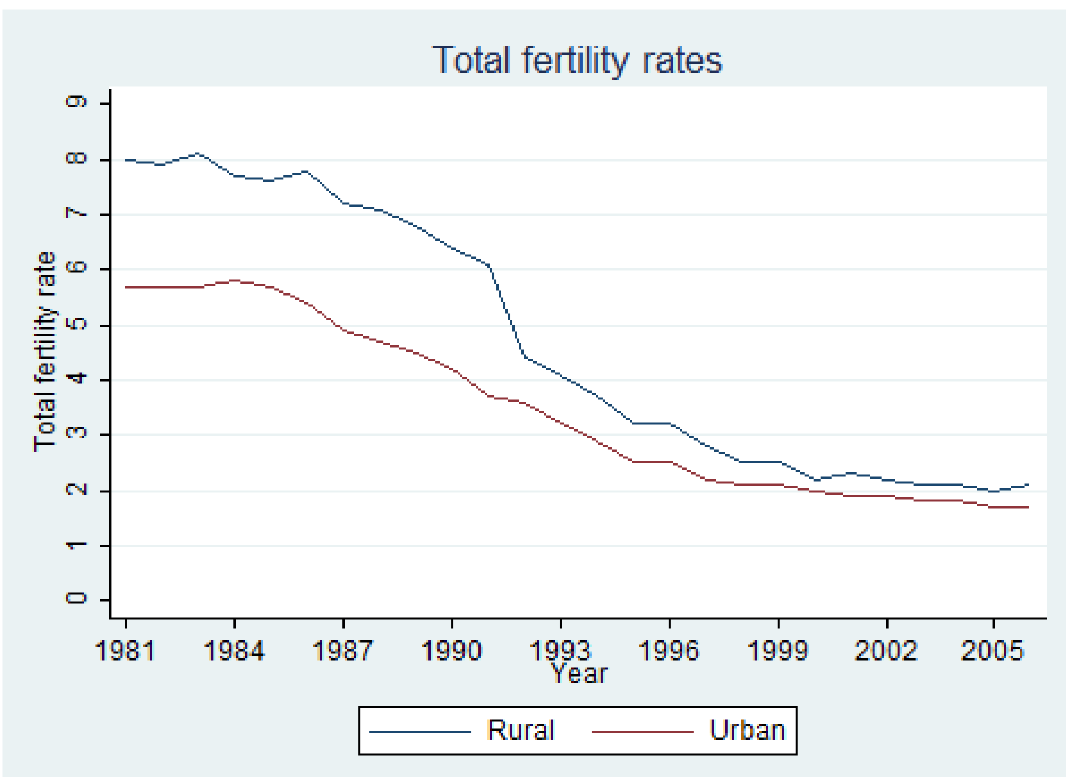
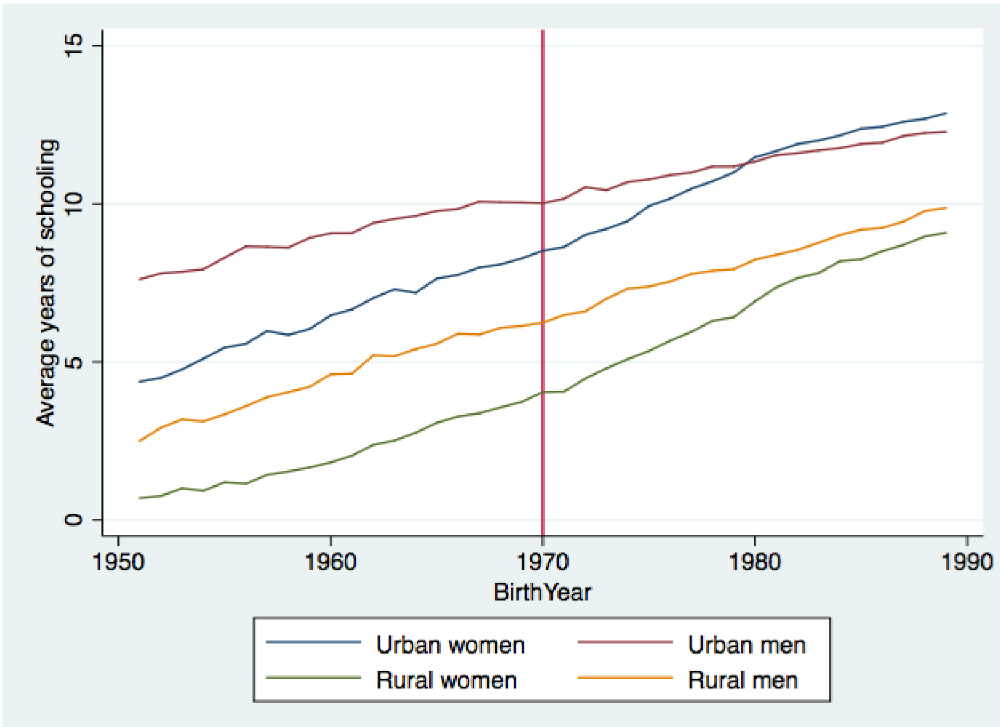


Figure 2: The narrowing gender gap in years of schooling in rural and urban areas



The evidence we present is from village-level data obtained from the national censuses of population in 1986 and 1996, the period during which most of the electricity expansion to rural areas took place. We measure the gender gap in literacy by the percentage of men and women 15-49 years old who are literate, and fertility by the child-woman ratio for about 13000 villages before and after the expansion of electrification. We have data on village topography for instrumenting for placement of electrification and other village characteristics that affect education and fertility, such as ethnicity. We match these village-level data with information on the year when electricity first arrived in each village.

The villages in our sample are known as the "main villages" that serve smaller satellite villages hamlets that span the entire rural Iran (for a description, see Salehi-Isfahani, Abbasi-Shavazi, and Hosseini-Chavoshi (2010)). Because of the semi-arid conditions of Iran, homes in these villages are close to each other so that access to electricity affects all residents equally. The highly subsidized price of electricity further ensures that the intra-village variation in access is minimal. These features ensure that intuitions about the impact of electricity on education and fertility derived from economic analysis of individual behavior apply to the village level.

The placement of electricity is not random. Larger villages with schools and health clinics, or potential to house them, are more likely to receive public infrastructure first (Salehi-Isfahani, Abbasi-Shavazi, and Hosseini-Chavoshi 2010). So, for causal identification we exploit the variation in the timing of extension of electricity to individual villages in two ways. First, we use the difference-in-differences (DID) method under the assumption that conditional on certain village characteristics, the trends in literacy rates and fertility are the same. Our control group is the group of villages without electricity in census year 1996 and the treatment group is defined by having received electricity between 1986 and 1996. If the assumption of similar parallel trends holds, the difference in changes in our outcome variables can be attributed to electrification. The DID results for female literacy and fertility conform to the common findings in the literature, villages electrified during the inter-censal period have larger increases in female education and decreases in fertility. However, the DID results also show something unusual: male literacy increases more in villages without electricity before or during the period under consideration. We interpret this finding as an indication that the parallel trends assumption might not be holding.

We argue that the DID estimates are likely to be biased because of the parallel trends assumption that underlies them may be violated. Villages that receive electricity earlier are likely to be on a faster development track with faster rising literacy and falling fertility than those that do not. The resulting bias may therefore reverse a potential positive effect of electrification on fertility.

This is indeed what our instrumental variable estimation (IV) reveals. In this estimation, we estimate the impact of years of access to electricity on literacy of men and women and fertility in 1996. The instrument we choose to control for the endogeneity of timing of electrification is variation in village elevation from the mean elevation of the district from the sea level. This instrument is well suited for our case because Iran is a mountainous country most of whose cities are situated at the foot of mountains with villages located above or below them. We assume that villages with elevation far from the mean are remote and their cost of extension of electricity is higher, so they receive electricity later. A similar instrument is used by Dinkelman (2011) to assess the impact of electrification on women's employment in South Africa. Village altitude, which is correlated with the cost of electrification and therefore the likelihood of having electricity earlier can be plausibly assumed not to influence fertility or female education directly. Grogan (2016) uses distance to hydro dams for the same purpose. The findings from IV estimation show that earlier access to electricity reduces the gender gap in literacy, the same as the DID results but without the anomaly we observed for male literacy. However, the IV results for fertility are the opposite of the DID results; they indicate that village-level fertility increases with a longer duration of access to electricity.

The plan of this paper is as follows. The next section describes rural electrification and the Iranian context, section 3 describes our data and provides the summary statistics, section 4 discusses identification and the implementation of DID and IV regressions, section 5 presents the empirical results using the two methods, and section 6 is the conclusion.

2 Electrification of rural Iran

Electrification was the most significant and visible aspect of the populist shift in public investment. During its first ten years (1978-1988) and despite the devastating war with Iraq that raged in the 1980s, the Islamic Republic raised the percentage of rural families with electricity from 22.6% to 68.5%, and during its second decade to 93.7% (Statistical Center of Iran, Expenditures and Income Surveys, various years, http://amar.sci.org.ir). The census of 1976 put the percentage of villages with access to electricity at 5.9%; in 1996 it had risen to 69.3%.

Following the Islamic Revolution, a grass-root organization called the Reconstruction Crusade (Jahad-e Sazandegi) composed of mostly volunteers but backed by the government aimed to redress

Table 1: Distribution of villages by the year of electrification

	Electrified villages	
Year of obs	Number	Percent
1966	653	1.50
1973	1360	3.12
1976	2588	5.93
1981	9793	22.44
1986	16899	38.71
1988	19494	44.66
1996	30260	69.32
2006	39845	91.28
No. of obs	43650	100

what the revolutionaries presumed was the Shah's neglect of the rural areas (Hooglund 2009; Lob 2018; Lob 2020). This organization, which was later merged with the Ministry of Agriculture and Rural Affairs, was tasked with building rural infrastructures, and electrification was its top priority. The pace of rural electrification picked up considerably after the revolution, increasing from 5.9 percent of all villages in 1976 to 22.4 percent in 1981, and later to 91 percent in 2006 (Table 1 and Figure 3).

Before the revolution, a wide gap in access to electricity separated rural and urban areas. According to the 1976 census of population, in rural areas, where the majority of the population lived, only percent of households had access to electricity, compared to 68.8 percent in urban areas. The same census counted only 653 villages, less than 2 percent of all villages, as having electricity in the 1960s (see Table 1).

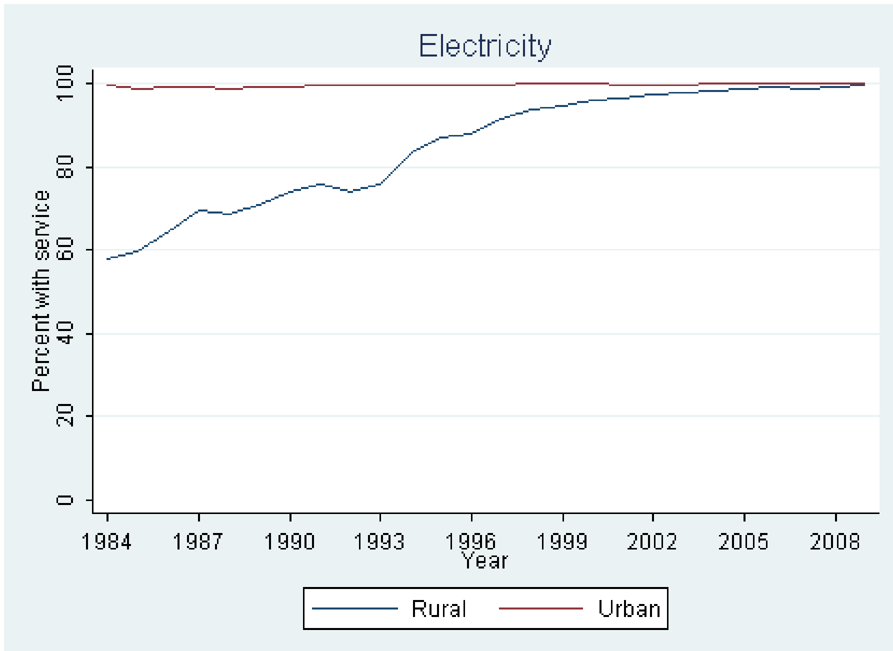
As noted earlier, the expansion of electricity network to new villages was likely not random. Larger villages and those closer to urban areas received priority, while smaller and less accessible villages received it later. The cost per household of providing electricity declined with population density, the distance of the village from existing electricity substations, and topography. All these make placement of the service endogenous. Following (Dinkelman 2011), we use of land gradient as an instrument to address the endogeneity of electrification into account in estimating the causal impact of electricity on fertility and female literacy.

After the revolution, electrification made a major expansion of rural schools and health clinics possible, though the health clinics were able to offer family planning services only after 1989, when the Islamic Republic reversed its opposition to family planning and started to promote smaller families. However, evidence of the direct effect of the clinics on fertility shows only a modest impact (Salehi-Isfahani, Abbasi-Shavazi, and Hosseini-Chavoshi 2010; Hashemi and Salehi-Isfahani 2013).

3 Data

Our unit of observation is the village. We have information on the year in which a village received electricity, its child-woman ratio, the literacy rate of women 15-49, and other characteristics such as availability of schools, roads, and geography. The data are from the national censuses of population

Figure 3: Rural-urban gap in household access to electricity, 1984-2009



Source: Authors' calculations using HEIS data files.

in 1986 and 1996. We have supplemented census information with data on availability of electricity and other village facilities from administrative data provided by the Ministry of Agriculture and Reconstruction. Data on fertility (child-woman ratio) and female literacy are from censuses of 1986 and 1996. These data have been previously used by Salehi-Isfahani et al. (2010) and Salehi-Isfahani (2013).

Our data include information on availability of schools (primary, middle and high school), health clinics, mosque, and population size. We also know the quality of the roads connecting the village to urban centers, and whether the village is located in the plains, mountain or forest, and if it has a Shia majority population.[1]

We measure village-level fertility with the child-woman ratio (CWR), the ratio of children less than 5 years of age to women aged 15 to 49. For smaller villages this variable is not a good proxy for fertility because small movements of population in and out of the village can cause large changes in the CWR unrelated to fertility. Each census of population counted approximately 120,000 villages in Iran, many of which are hamlets and small settlements. We exclude villages with fewer than 100 people because we cannot estimate their fertility level with CWR accurately.

For the DID estimation we set up a quasi-experiment in which villages without electricity in 1986 are divided into two groups of program (treated) that received electricity by 1996 and Comparison (untreated) that did not [2]. As a result, we lose 13,090 villages that had electricity before 1986 or

[1]Shia is the majority of Islam sect in Iran and contains about 90 percent of the population.

[2]The data on rural electrification shows that a main phase of electrification expanded during 1986 to 1996 (table 3). So we define our treatment as receiving electricity during this period.

received it after 1996. Then the impact of the treatment on the outcomes under consideration is examined for the years 1986 and 1996, that is the changes in CWR and in literacy rates during 1986-1996 are compared for control and program villages.

The sample for IV estimation relies on the earliest year in which a village was listed as having electricity. This does not identify the year that it first had electricity because our data cover specific years only. As a result, the distribution of the years of exposure is not smooth. The IV identification strategy takes advantages of village elevation, which is an exogenous variation in the cost of extending rural electricity. The data on elevation of villages was downloaded from the website of National Cartographic Center of Iran. Data on 24,625 villages is available from this source. Merging the data set of village elevation with our village data on facilities and demographic characteristics decreases the sample size to about 14,400 villages in our IV estimation sample.

Table 2 shows the summary statistics for the DID sample by treatment status. About 32 percent of the DID sample are comparison villages and the rest are program ones. The data indicates that CWR is lower in program villages compared to the control ones in 1986 (0.98 vs 1.02) and declines dramatically in both groups during 1986-96. But this decline is greater for program villages. These villages are also on average larger, and have higher probability of having schools, mosque, shia majority in 1986, and easier access to their close towns. The health house coverage in 1986 at district level is greater for treated villages. The t-statistics of comparing mean village characteristics between program and control villages along with their corresponding two-tailed p-values are presented in the last two columns of the table. The t-tests suggest that the differences in means for each village characteristic between two groups are significantly different from 0. More interestingly, there are significant differences between geographical characteristics of these groups of villages. About 35 percent of the electrified villages are in the plain and about 60 percent are located in mountainous terrain, while unelectrified villages are mostly mountainous (83 percent).

The differences in village characteristics in 1986 between the two groups indicate selection in electricity provision during 1986-1996. Village population, schools availability, religion, and health clinic coverage (correlated with the development level of the villages), as well as topographical conditions are associated with access to electricity in 1986. Therefore, these characteristics are controlled in our DID estimation to make the comparison between similar villages and try to make the electrification placement exogenous.

Table 3 shows the summary statistics for the IV sample. Average CWR for the sample of all villages is 970 children per 1000 women in 1986, declining to 510 in 1996. We include information on population, village years of exposure to electricity, primary, middle and high school till 1996 and religion characteristics for the year 1986. The mean population of the whole sample is 600 persons. Villages are having electricity on average for 9 years till 1996 but they have been exposed to primary school for longer period (26.40 years). The data indicates that an average village receives middle school and high school after provision on electricity. The religion variables show that 83 percent of the villages have mosque in the year 1986 and in 89 percent of them Shia is the majority of population. The data on geographic characteristics indicates that 50 percent of sample villages are located on plain area, 49 percent on mountain and only 2 percent on forest.

The village level data capture well the changes in fertility over the 1986-1996 period that we observe from household level data (Abbasi-Shavazi et al. (2009), Salehi-Isfahani et al. 2010). The

Table 2: Summary statistics for DID estimations of fertility

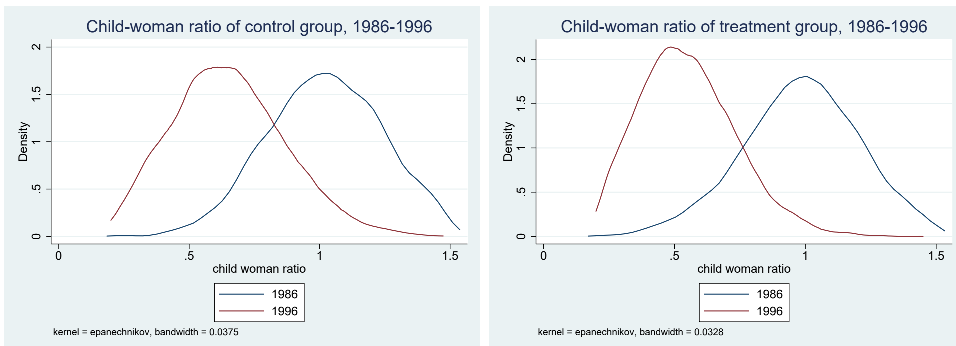
	Full sample		Control		Program		t-test	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	t-stat	p-value
Child-woman ratio 86	0.99	0.22	1.02	0.22	0.98	0.22	8.63	0.00
Child-woman ratio 96	0.58	0.20	0.65	0.22	0.55	0.18	26.96	0.00
Village population 86	387.52	344.64	286.61	249.85	434.76	371.71	-22.95	0.00
Health house coverage 86	1.10	0.81	1.07	0.74	1.11	0.84	-2.74	0.01
TV 96	0.76	0.43	0.44	0.50	0.91	0.28	-68.46	0.00
Proportion of villages with								
Primary school	0.93	0.25	0.89	0.32	0.95	0.21	-14.52	0.00
Middle school	0.09	0.29	0.04	0.19	0.12	0.32	-14.36	0.00
High school	0.01	0.11	0.00	0.07	0.02	0.13	-5.59	0.00
Mosque	0.76	0.42	0.69	0.46	0.80	0.40	-13.83	0.00
Shia majority	0.78	0.41	0.70	0.46	0.82	0.38	-15.28	0.00
Asphalt road	0.42	0.49	0.19	0.39	0.53	0.50	-38.33	0.00
Village geography								
Plain	0.29	0.45	0.16	0.36	0.35	0.48	-22.79	0.00
Mountain	0.69	0.46	0.83	0.37	0.63	0.48	23.79	0.00
Forest	0.02	0.12	0.01	0.09	0.02	0.14	-4.76	0.00
No. of observations	12594		4016		8578			
Degrees of freedom							12592	

Table 3: Summary statistics for OLS and IV estimations of fertility

	Mean	Std. Dev.	Min	Max
Child-woman ratio 86	0.97	0.23	0.20	1.50
Child-woman ratio 96	0.51	0.18	0.20	1.36
Village population	600.03	601.41	100	7545
Electricity exposure 96	9.09	6.64	0	30
Elevation	1.32	0.68	-0.10	2.95
TV 96	0.88	0.33	0	1
Primary school exposure 96	26.40	8.16	0	46
Middle school exposure 96	3.68	7.50	0	30
High school exposure 96	1.14	5.38	0	30
Proportion of villages with				
Mosque	0.83	0.38	0	1
Shia majority	0.89	0.32	0	1
Asphalt road	0.66	0.47	0	1
Village geography				
Plain	0.50	0.50	0	1
Mountain	0.49	0.50	0	1
Forest	0.02	0.12	0	1
No. of observations	14416			

figure 4 shows the evolution of the distribution of village child-woman ratios by treatment status. In 1986, the distributions of CWRs are almost the same between control and treatment groups with greater mean in control villages. By 1996, the CWR distribution of both groups had shifted to the left but the corresponding shift in treatment group is more striking.

Figure 4: The distribution of villages by child-woman ratio



Turning to literacy, we present the summary statistics for DID and IV samples of literacy in Table 4 and Table 5 , and the distribution of villages by their literacy rates for men and women aged 15-49 in Figure 5. The samples for fertility and literacy estimations differ because data for CWR and literacy did not exist for all villages. Table 4 shows the faster increase in female literacy, which trebled, rising from 17 percent in 1986 to 52 percent in 1996, compared to male literacy which increased from 49 to 76 percent. (The rest of this table shows the characteristics of the villages, which are very similar to the sample for CWR.) The same difference is observed in Figure 5, which shows the distributions of villages by female literacy for control and treatment groups in the top row and those for men in the bottom row. Notice that the shift in the distribution of literacy rates for women is more pronounced than men.

4 Methodology

4.1 Identification

As a mountainous and arid country, many of Iran's villages and towns are located at the foot of mountains where water from aquifers are tapped for irrigation (Manuel, Lightfoot, and Fattahi 2018). As a result, there is considerable variation in the elevation of, and therefore access to, these villages. The variation in elevation generates variation in the cost of electricity provision which is uncorrelated with the outcomes of interest, education and fertility. We take advantage of this variation to identify the exogenous effect of electricity on fertility and education. To more closely reflect the cost, we measure the difference in elevation between each village and the mean elevation of villages in the district, which approximates the center of the electricity grid in the area.

Table 6 shows the relationship between the timing of electrification and village elevation. In 1986, villages with electricity were on average below district mean while those without were above.

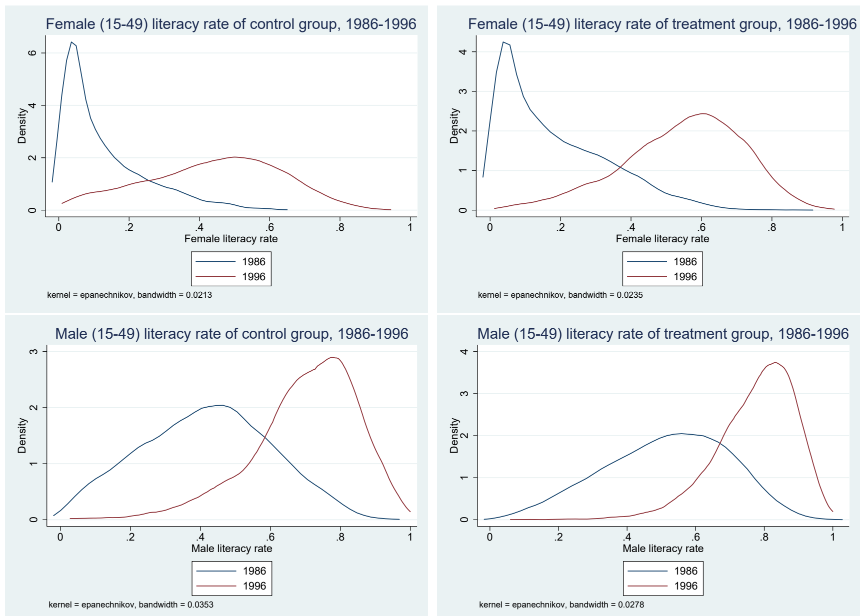
Table 4: Summary statistics for DID estimations of literacy

	Full sample		Control		Program		t-test	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	t-stat	p-value
Female literacy rate 86	0.17	0.15	0.13	0.12	0.18	0.15	-15.99	0.00
Female literacy rate 96	0.52	0.18	0.44	0.19	0.55	0.17	-25.08	0.00
Male literacy rate 86	0.49	0.19	0.42	0.18	0.51	0.18	-22.44	0.00
Male literacy rate 96	0.76	0.13	0.70	0.15	0.78	0.12	-24.36	0.00
Literacy gap 86	0.32	0.14	0.29	0.15	0.33	0.14	-12.50	0.00
Literacy gap 96	0.24	0.14	0.26	0.15	0.23	0.13	9.65	0.00
Village population 86	421.76	360.65	321.23	299.76	455.70	372.96	-15.61	0.00
TV 96	0.82	0.39	0.48	0.50	0.93	0.25	-56.20	0.00
Proportion of villages with								
Primary school	0.96	0.20	0.94	0.24	0.96	0.19	-4.46	0.00
Middle school	0.12	0.33	0.06	0.24	0.14	0.35	-10.39	0.00
High school	0.02	0.13	0.01	0.08	0.02	0.14	-4.78	0.00
Mosque	0.79	0.41	0.70	0.46	0.82	0.39	-11.77	0.00
Shia majority	0.85	0.36	0.78	0.41	0.87	0.34	-10.24	0.00
Asphalt road	0.49	0.50	0.23	0.42	0.58	0.49	-29.87	0.00
Village geography								
Plain	0.32	0.47	0.19	0.39	0.37	0.48	-15.92	0.00
Mountain	0.66	0.47	0.80	0.40	0.61	0.49	16.92	0.00
Forest	0.02	0.13	0.01	0.09	0.02	0.15	-4.13	0.00
No. of observations	9041		2282		6759			
Degrees of freedom							9039	

Table 5: Summary statistics for OLS and IV estimations of literacy

	Mean	Std. Dev.	Min	Max
Female literacy rate 86	0.27	0.18	0.00	0.96
Female literacy rate 96	0.64	0.16	0.02	1
Male literacy rate 86	0.60	0.18	0.01	1
Male literacy rate 96	0.82	0.11	0.04	1
Literacy gap 86	0.33	0.13	-0.23	0.84
Literacy gap 96	0.18	0.12	-0.33	0.72
Village population 86	635.41	600.08	100	7372
Electricity exposure 96	9.99	6.56	0	30
Elevation	1.27	0.69	-0.03	2.95
TV 96	0.92	0.27	0	1
Primary school exposure 96	27.21	7.55	0	46
Middle school exposure 96	4.27	7.98	0	30
Proportion of villages with				
Mosque	0.84	0.37	0	1
Shia majority	0.94	0.24	0	1
Asphalt road	0.72	0.45	0	1
Village geography				
Plain	0.54	0.50	0	1
Mountain	0.45	0.50	0	1
Forest	0.02	0.13	0	1
No. of observations	11540			

Figure 5: The distribution of villages by level of female and male literacy



In later years, those without electricity are located at higher elevations and those with are closer to the mean district elevation.

Table 6: Village elevation and electrification status

	1986		1996		2006	
	No elect.	Electrified	No elect.	Electrified	No elect.	Electrified
Elevation	1.38	1.27	1.41	1.31	1.36	1.33
	(0.66)	(0.70)	(0.62)	(0.69)	(0.60)	(0.68)
Deviation in elevation	0.04	-0.05	0.08	-0.02	0.08	-0.00
	(0.29)	(0.24)	(0.33)	(0.25)	(0.37)	(0.27)
No. of obs	11112	9177	4246	16043	648	19641

Note: Standard deviations are in parentheses. Elevation is altitude from the sea level measured in kilometers. Deviation in elevation is the difference in elevation between the village and the nearest urban center.

Supply of electricity services influence the development of a location but also depend on the locality's development status. In the case of rural Iran, where the government is the sole supplier, its objectives affect whether to extend electricity to the more or less developed areas first.

Our identification strategy is based on the timing of arrival of electricity in the village. We use this variable in binary form – having received electricity during a ten year interval (1986-1996) or not– in the difference-in-differences regressions and as years of exposure to electricity in the IV regressions. Measured as years of exposure allows us to deal with the endogeneity of program placement using the instrumental variables technique. Our instrument measures the difference between the elevation of the village from the sea and the mean elevation of the district in which the village is located. We believe that this variable is correlated with the timing of the extension of electricity but not directly correlated with education or fertility.

4.2 Difference-in-differences

We begin with the DID estimator which has a more straightforward interpretation. Assuming that treatment is random and the underlying average trend in the outcome of interest is the same for treated and untreated groups of villages, one can attribute any differences in the trends between the two groups to treatment. The first assumption is less restrictive. The more one can account for the initial difference between the two groups, so that one can think of treatment as randomly assigned. The second assumption, known as parallel trends is not testable and has to be maintained in order to interpret the results.

The idea of DID method in identifying the effect of electrification is to compare the decrease in each outcome between program and comparison groups. In difference-in-difference estimation the first difference is over time for each group which eliminates the effect of unobservable time invariant factors on village fertility. The second difference is the difference between these differences. In order to compare fertility between observationally equivalent villages that only differ in the timing of their electrification, the observable differences between groups have to be controlled. We do this by controlling the village characteristics that differ between two groups in Table 2.

The following formulation of the DID estimator closely follows Wagstaff et al. (2009) and Salehi-Isfahani et al. (2010). It relates the outcome of interest (village-level literacy and fertility) to village characteristics, year of observation, and treatment status. For program villages this relation can be written as:

$$Y_{it}^P = H_{it} + f(X_{it}) + \mu_i^P + \theta_t^P + u_{it}^P,$$

where Y_{it}^P is the outcome in village i in year t= 1986 and 1996, H_{it} is fertility decline or increase in literacy due to the presence of electricity, X_{it} are a vector of observable village characteristics that influence these outcomes, μ_i^P captures the unobservable, village-specific effects that are potentially correlated with program status, and θ_t^P is the time-specific effect. The same relation for comparison villages is ($H_{it} = 0$):

$$Y_{it}^C = g(X_{it}) + \mu_i^C + \theta_t^C + u_{it}^C$$

Calculating the changes in each outcome between 1986 and 1996 for each group eliminates the μs (we also drop the time subscript because we compare only two periods):

$$\Delta Y_i^P = H_i + f(\Delta X_i) + \Delta\theta^P(X_i) + \Delta u_i^P,$$

$$\Delta Y_i^C = g(\Delta X_i) + \Delta\theta^C(X_i) + \Delta u_i^C$$

The DID estimator is then simply the difference between these differences:

$$\Delta Y_i^P - \Delta Y_i^C = H_i + f(\Delta X_i) - g(\Delta X_{it}) + \Delta\theta^P - \Delta\theta^C + \Delta u_i^P - \Delta u_i^C \tag{1}$$

The simplest formulation of DID omits X's from 1 (as in Wooldridge 2002). In our case the X's are set in 1986, so they are eliminated by the first differencing. Some of the X's, such as religion, simply do not change while others influence the outcomes only slowly, so we keep them in the DID regressions because we believe that they influence not just the level but also the trends in fertility and literacy. In other words, we assume that the parallel trends assumption ($\Delta\theta^P - \Delta\theta^C = 0$) holds conditional on observable village characteristics.

Thus, the DID regression takes the following form, with X's on the right hand side:

$$Y_{it} = \alpha + \beta D_{it} + \gamma Year + \delta(D_{it} * Year) + X_{it}\psi + \epsilon_{it} \tag{2}$$

where Y_{it} is the child-woman ratio (or the literacy rate) of village i in year t, D is a dummy variable which takes the value of one if the village has electricity in year t (1996), $Year = 1$ if 1996 and zero otherwise. The value of β is the estimate of the initial difference in CWR and literacy between program and comparison villages, γ is the common time trend, and δ is the program effect, which is the DID estimator.

The binary use of electricity availability is dictated by the fact that we observe village level fertility and literacy only in census years 1986 and 1996. It may be argued that villages that received electricity later in this period, say in 1995, should be counted in the comparison group. We examine the sensitivity of our results in this regard by reassigning the villages with a short duration of electrification from treatment to control. The results do not change significantly. We also try a non-binary approach and estimate the effect of the number of years that electricity is present on fertility and literacy. Again, our results do not change. We use district-level fixed effects to factor out unobservable impacts which are fixed within each district but differ between them.

We also use propensity score matching to further refine how observable village characteristics affect the outcomes of interest. The results are very similar to DID; in particular, the anomalous DID result that male literacy declines with treatment remains.

4.3 Instrumental variables

The anomalous DID results for male literacy raise alarm about bias in the DID results. To reduce the bias, we would like to instrument for the timing of expansion of electricity to each village. But there is no easy way to combine IV estimation with DID, so we recast our regressions in terms of the effect of intensity of treatment, measured by the number of years before 1996 that the village had electricity, on each outcome. Our instrument is village elevation deviation from its district mean to instrument for electricity exposure, as explained in section 3. We control for the number of years, until 1996, that villages had primary, middle and high school, as well as other village characteristics in 1986. Our identification assumption is that conditional on these characteristics, deviation of village altitude from district mean should not affect fertility or literacy rates except through electrification.

The first-stage regression for electricity exposure of village i is therefore:

$$E_i = \alpha_0 + \alpha_1 Z_i + \alpha_2 X_i + \upsilon_i \tag{3}$$

where E_i is the number of years of electricity exposure by the time of observation in 1996, Z_i is village elevation from the sea level (instrumental variable), and X_i is a set of village characteristics.

The second-stage equation of estimation is:

$$Y_{it'} = \alpha + \beta \hat{E}_i + X_i \psi + \epsilon_i \tag{4}$$

where t' is 1996, and $\hat{E}_i$ is the estimation of years of electricity exposure till 1996 which yields from the first stage. The coefficient of interest β shows the changes in CWR for each additional year of exposure to electricity. We control for district-level fixed effect in our regressions so our instrumental variable, village elevation, is interpreted as deviation of village elevation from its district mean. The electricity mostly extended from the existing substation infrastructures and high voltage lines. These substations are distributed over district and are not necessarily located in main cities. As a result, mean district elevation is acceptable as the base of our elevation comparison.

5 Results

We divide the presentation of our results by outcome and begin with literacy.

5.1 Literacy

5.1.1 DID

We report our results by estimation method, beginning with DID. The DID method compares changes in the village literacy rates or fertility during 1986-96 between villages that did not have electricity in 1986 and 1996 (control) with those that did receive electricity sometime during 1986-96 (treatment).

The DID results for male and female literacy based on equation 2 are presented in Tables 7 and 8. Three different specifications of the DID regression are reported here. Columns 1 and 2 differ in the list of controls and column 3 uses fixed effects. It is reassuring that estimates of the "program effect" are the same in all three regressions. The smaller coefficient of "program village", which captures the mean difference in literacy rates between the two groups, suggests that conditioning on the controls reduces the overall bias due to endogeneity.

The comparison of male and female DID regressions shows that the coefficients for program effect (third row) are of opposite signs. In the case of women, as expected, access to electricity increases literacy, but for men it reduces literacy, which makes little sense. We take this to be evidence of bias in the DID results, and not the adverse impact of electricity. Two reasons for this result come to mind. First, because male literacy rate is higher and therefore closer to the ceiling of 100 percent, further increases in male literacy are necessarily smaller. However, this does not seem sufficient to account for a bias large enough to overturn what one expects to be sizeable positive impact into negative. In the majority of villages male literacy is below 50 percent in 1986 with enough room to grow. The average for village male literacy rate was 49% in 1986 and went up to 76% in 1996 (see Figures 5). The second and more important reason may be bias in the DID estimates resulting from unobserved differences between the control and treated villages which may have violated of the parallel trends assumption. Villages with electricity in 1986 are in a better position to increase their literacy rates, for men and women, than those without electricity. To deal with this problem, in the next subsection we turn to IV estimation.

But before doing that, consider the results from combining the estimates for men and women into one variable measuring the impact of electricity on the gender gap in literacy (Table 9, and results from propensity score matching that show a different way of comparing differences in differences (Table 10. Better matching of control and treated samples can reduce the bias due to divergent trends (Ryan, Kontopantelis, Linden, and Burgess Jr 2019). Both sets of results reproduce the DID results we have already discussed. The first set indicate that the program effect on the gap (male minus female literacy) is negative, and the second reproduces the anomalous negative impact for male literacy.

5.1.2 IV

We offer the results of the IV method as evidence that better control for endogenous program placement (see Tables 11 and 12). suggest do a better job reducing bias arising from . in appear to confirm this conjecture. First, notice that in IV regressions we switch from the binary variable for electrification to a continuous one measuring years of exposure to electricity. Next, notice that the first stage results in column 3 show that our instrument is valid because it is negatively related to the timing of electrification. The relevancy of the instrument is tested by F-statistics once all controls have been accounted for. Since F-statistics at the first stage is larger than 10 (81.37), the instrument would be a potentially strong one. A one kilometer increase in village elevation difference from district mean level reduces the exposure to electricity by 2.13 years.

Unlike the DID regressions, which showed opposite effects for men and women, the impact of exposure to electricity on village literacy in IV regressions is positive for both men and women. In the OLS regressions which are presented as a benchmark in column 1, each year of exposure to electricity increases the proportion of literate women in the village by 0.007. This is increased to 0.025 when we control for the endogeneity. Areas with higher exposure may have been more developed and more literate to begin with, which explains why the impact according to OLS is so small. The 2SLS (IV) estimate suggest that extension of electricity to a village with 50 percent female literacy rate to 75 percent in ten years. Significantly, for women it is 40 percent larger than men. The same number for men is to go from 50 to 65 percent.

The difference in the size of the impact of electricity for men and women makes sense on two grounds. First, there is a mechanical observation. Because the literacy rates is capped at 1, and men's literacy is higher, the gains are necessarily smaller for men.

Second and more substantively, electricity affects the time use of men and women differently, leading to a difference in impact on education. For example, the availability of time-saving appliances, such as refrigerators, washing machines and vacuum cleansers, frees up more time for women than men and may thus help narrow the gender gap in educational attainment (Bailey and Collins 2011).

5.2 Fertility

5.2.1 DID

As with literacy, we begin with the DID results. Table 14 presents the results from three different equations. The estimates in column 1 are the unconditional DID results, which in principle are not valid because they do not control for program placement. The average decline in CWR is 368 children per 1000 women and the initial difference in CWR between the program and comparison groups is 37 children per 1000 women. The program effect estimated at 64 children per 1000 women. Adding the controls in column 2 reduces the difference in CWR between the two groups to 10 children per 1000 women, which indicates that our conditioning is effective. The common time trend and the program effect do not change. The last column controls for district-level fixed effects, in which the initial gap in fertility between the program and comparison groups disappears.

Other village characteristics on availability of schools, mosque and Shia majority have expected signs from development aspect. Villages with primary school, middle school and high school have significantly lower CWR. Availability of Mosque can be interpreted as religiosity or the wealth of the village. If the later is true, it provides evidence that richer villages have lower fertility. Defining a village in Shia majority decreases CWR as well. Predictably, whether the village is located on mountain is not correlated with village fertility. The larger the number of health houses per 1000 women in district the lower child-woman ratio in village. This coefficient confirms the effect of family planing provision on fertility of rural women.

As before, we use PSM to measure the impact of electrification on fertility (see Table 15. As expected, the estimated impact is similar to DID, ie negative.

5.2.2 IV

The OLS and IV estimates are presented in Table 16 using years of exposure to electricity until 1996 as treatment. As before, we present the OLS results in column 1 serve as a benchmark, showing that the impact of exposure to electricity is 3 fewer children per 1000 women per year. As we noted in the case of literacy, this estimate is biased downward since more developed villages and those closer to cities that were more likely to access electricity earlier happen to have had lower fertility to begin with. As a result, the impact appears to be negative. This is apparent in regression in columns 2 (2SLS) that use land gradient as instrument. The impact of exposure in this regression is the opposite of both OLS and DID results. In column 2, the program impact is to *add* 14 children per 1000 women per year.

The OLS estimations of village characteristic coefficients mostly appear with expected signs. Predictably, larger years of exposure to primary school and middle school significantly decrease fertility. Villages with mosque and Shia majority in 1986 have lower CWR in 1996 indicating higher acceptance of Islamic government messages. Villages on mountain and forest indicate less fertility than plain villages. As expected, villages that are connected to towns by asphalt roads are more likely to have smaller CWR as a result of more access to health centers and facilities. IV estimates of schooling exposure coefficients, mosque, Shia majority and asphalt road are consistent with OLS results though showing larger effects on fertility. Exposure to high school and village located on forest have no significant effect. We examined the robustness of the IV results by controlling for child-woman ratio 1986 in Table 16 and the results do change.

Finally, television has been identified as an important ideational influence on family behavior, persuading families to believe that social and economic upward mobility requires family planning. Although our study is not designed to evaluate the impact of TV per se, when we include it as a control, we find that its availability in the village (not ownership of a TV) negatively affects fertility, a result that has been found elsewhere Jensen and Oster (2009).

6 Conclusions

The dramatic improvements in gender equity in education and in fertility that has transformed the lives of rural women in Iran, the majority of women before the revolution, have occurred despite efforts to by the Islamic revolution to limit their role in society to mothers and homemakers. In this paper we ask if electrification, which is also a policy promoted by the revolutionaries, may have helped female empowerment. During its first decade, the Islamic Republic redirected investment toward under privileged areas and built basic infrastructure –road, health clinics, schools – which led to a dramatic decline in fertility and rise of female education in rural areas in the 1990s.

The main challenge in identifying the impact of infrastructure on household behavior is that its placement is rarely random, so researchers must be careful to determine what would have been the impact if placement had been random. We employ DID and instrumental variables methods to obtain unbiased estimates of impact.

We find that electrification increased village literacy rates for male and female adults, but had a larger impact on the latter. On fertility, where the two methods produce different estimates, We prefer the IV estimates that show a positive impact. We argued that the DID results that showed the usual negative impact on fertility are likely biased. What this finding suggests for the impact of electrification on female empowerment is that on its own access to electricity does not reduce fertility, though its overall effect is to reduce it because it increases female education and reduces the gender gap in education.

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Table 7: DID estimates of the impact of access to electricity on literacy, women

	(1)	(2)	(3)
Program village	0.056**	0.016**	0.024**
	(0.003)	(0.003)	(0.003)
Time trend	0.314**	0.314**	0.314**
	(0.005)	(0.004)	(0.004)
Program effect	0.051**	0.051**	0.051**
	(0.005)	(0.005)	(0.004)
TV exposure		0.025**	0.032**
		(0.003)	(0.003)
Village had in 1986			
Primary school		0.025**	0.034**
		(0.006)	(0.005)
Middle school		0.094**	0.056**
		(0.004)	(0.003)
High school		0.038**	0.029**
		(0.009)	(0.008)
Mosque		0.048**	0.039**
		(0.003)	(0.004)
Shia majority		0.101**	0.051**
		(0.003)	(0.004)
Village geography			
Mountain		-0.031**	-0.021**
		(0.003)	(0.002)
Forest		0.050**	-0.025**
		(0.009)	(0.007)
Asphalt road		0.039**	0.028**
		(0.002)	(0.002)
Log population		-0.046**	-0.029**
		(0.002)	(0.002)
Constant	0.127**	0.248**	0.181**
	(0.003)	(0.011)	(0.011)
R^2	0.554	0.619	0.741
Observations	18082	18082	18082

Notes: Column 3 is district-level fixed effects. TV exposure is a binary variable indicating availability of TV signal in the village in 1996. Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$.

Table 8: DID estimates of the impact of access to electricity on literacy, men

	(1)	(2)	(3)
Program village	0.099**	0.061**	0.064**
	(0.004)	(0.005)	(0.004)
Time trend	0.284**	0.284**	0.284**
	(0.005)	(0.005)	(0.004)
Program effect	-0.024**	-0.024**	-0.024**
	(0.006)	(0.005)	(0.005)
TV exposure		0.025**	0.029**
		(0.004)	(0.004)
Village had in 1986			
Primary school		0.059**	0.055**
		(0.007)	(0.006)
Middle school		0.083**	0.059**
		(0.003)	(0.003)
High school		0.034**	0.033**
		(0.008)	(0.008)
Mosque		0.028**	0.047**
		(0.003)	(0.004)
Shia majority		0.085**	0.039**
		(0.003)	(0.004)
Village geography			
Mountain		-0.020**	-0.020**
		(0.002)	(0.003)
Forest		0.012	-0.021**
		(0.009)	(0.008)
Asphalt road		0.037**	0.026**
		(0.002)	(0.002)
Log population		-0.033**	-0.024**
		(0.002)	(0.002)
Constant	0.416**	0.446**	0.430**
	(0.004)	(0.012)	(0.012)
R^2	0.439	0.503	0.576
Observations	18082	18082	18082

Notes: Column 3 is district-level fixed effects. TV exposure is a binary variable indicating availability of TV signal in the village in 1996. Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$.

Table 9: DID estimates of the impact of access to electricity on the gender gap in literacy

	(1)	(2)	(3)
Program village	0.042**	0.045**	0.040**
	(0.003)	(0.004)	(0.004)
Time trend	-0.030**	-0.030**	-0.030**
	(0.004)	(0.004)	(0.004)
Program effect	-0.074**	-0.074**	-0.074**
	(0.005)	(0.005)	(0.005)
TV exposure		-0.000	-0.003
		(0.003)	(0.003)
Village had in 1986			
Primary school		0.034**	0.021**
		(0.006)	(0.006)
Middle school		-0.011**	0.003
		(0.003)	(0.003)
High school		-0.003	0.003
		(0.007)	(0.007)
Mosque		-0.020**	0.007*
		(0.003)	(0.004)
Shia majority		-0.016**	-0.012**
		(0.003)	(0.004)
Village geography			
Mountain		0.011**	0.000
		(0.002)	(0.002)
Forest		-0.037**	0.004
		(0.006)	(0.006)
Asphalt road		-0.002	-0.003
		(0.002)	(0.002)
Log population		0.014**	0.005**
		(0.002)	(0.002)
Constant	0.289**	0.198**	0.249**
	(0.003)	(0.011)	(0.011)
R^2	0.098	0.110	0.235
Observations	18082	18082	18082

Notes: Column 3 is district-level fixed effects. TV exposure is a binary variable indicating availability of TV signal in the village in 1996. Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$.

Table 10: Propensity score matching estimates of the impact of access to electricity on literacy

Variable	Sample	Treated	Controls	Difference	S.E.
Change in female literacy rate 1986-1996	Unmatched	0.364	0.314	0.050	0.003
	ATT	0.364	0.342	0.022	0.007
Change in male literacy rate 1986-1996	Unmatched	0.262	0.284	-0.022	0.004
	ATT	0.262	0.295	-0.033	0.007
Change in literacy gap 1986-1996	Unmatched	-0.102	-0.030	-0.072	0.004
	ATT	-0.102	-0.046	-0.055	0.009

Table 11: IV estimates of the impact of access to electricity on female literacy

	OLS		2SLS	
Electricity exposure 96	0.006**	0.002**	0.026**	0.019**
	(0.000)	(0.000)	(0.004)	(0.005)
Female literacy rate 86		0.487**		0.298**
		(0.008)		(0.054)
Primary school exposure 96	0.002**	0.000*	0.001*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Middle school exposure 96	0.002**	0.000	-0.000	-0.001**
	(0.000)	(0.000)	(0.000)	(0.000)
TV exposure	0.061**	0.048**	-0.015	-0.006
	(0.005)	(0.005)	(0.018)	(0.016)
Village had in 1986				
Mosque	0.040**	0.028**	0.029**	0.024**
	(0.004)	(0.004)	(0.006)	(0.005)
Shia majority	0.027**	0.015**	0.021**	0.015*
	(0.006)	(0.005)	(0.007)	(0.006)
Village geography				
Mountain	-0.026**	-0.019**	0.007	0.004
	(0.003)	(0.002)	(0.008)	(0.007)
Forest	-0.014	-0.010	0.006	0.004
	(0.008)	(0.007)	(0.012)	(0.010)
Asphalt road	0.037**	0.024**	-0.002	-0.002
	(0.003)	(0.003)	(0.009)	(0.008)
Log population	-0.018**	-0.001	-0.052**	-0.034**
	(0.002)	(0.002)	(0.008)	(0.010)
Constant	0.505**	0.386**	0.635**	0.547**
	(0.012)	(0.010)	(0.040)	(0.048)
R2	0.552	0.668	0.223	0.450
Observations	11540	11540	11540	11540

Notes: Dependent variable in OLS and 2SLS regressions is female literacy rate (1996). Regressions are district-level fixed effect. Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$.

Table 12: IV estimates of the impact of access to electricity on male literacy

	OLS		2SLS	
Electricity exposure 96	0.003**	0.001**	0.016**	0.011**
	(0.000)	(0.000)	(0.003)	(0.003)
Male literacy rate 86		0.340**		0.269**
		(0.006)		(0.025)
Primary school exposure 96	0.002**	0.000**	0.001**	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Middle school exposure 96	0.001**	-0.000	-0.000	-0.001**
	(0.000)	(0.000)	(0.000)	(0.000)
TV exposure	0.041**	0.025**	-0.010	-0.007
	(0.005)	(0.004)	(0.014)	(0.012)
Village had in 1986				
Mosque	0.032**	0.019**	0.024**	0.016**
	(0.004)	(0.003)	(0.005)	(0.004)
Shia majority	0.003	-0.004	-0.001	-0.005
	(0.005)	(0.004)	(0.006)	(0.004)
Village geography				
Mountain	-0.014**	-0.008**	0.008	0.007
	(0.002)	(0.002)	(0.006)	(0.005)
Forest	-0.007	-0.005	0.006	0.004
	(0.007)	(0.006)	(0.009)	(0.007)
Asphalt road	0.024**	0.013**	-0.002	-0.003
	(0.002)	(0.002)	(0.007)	(0.006)
Log population	-0.012**	0.000	-0.035**	-0.018**
	(0.001)	(0.001)	(0.006)	(0.006)
Constant	0.729**	0.552**	0.828**	0.662**
	(0.010)	(0.009)	(0.031)	(0.040)
R2	0.345	0.517	0.026	0.352
Observations	11540	11540	11540	11540

Notes: Dependent variable in OLS and 2SLS regressions is male literacy rate (1996). Regressions are district-level fixed effect. Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$.

Table 13: IV estimates of the impact of access to electricity on the gender gap in literacy

	OLS		2SLS	
Electricity exposure 96	-0.003**	-0.002**	-0.009**	-0.009**
	(0.000)	(0.000)	(0.003)	(0.003)
Literacy gap 86		0.219**		0.208**
		(0.008)		(0.010)
Primary school exposure 96	0.000	-0.000	0.001*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Middle school exposure 96	-0.001**	-0.001**	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
TV exposure	-0.020**	-0.024**	0.005	0.001
	(0.005)	(0.005)	(0.013)	(0.013)
Village had in 1986				
Mosque	-0.009*	-0.012**	-0.005	-0.008
	(0.004)	(0.003)	(0.004)	(0.004)
Shia majority	-0.024**	-0.023**	-0.021**	-0.021**
	(0.005)	(0.005)	(0.005)	(0.005)
Village geography				
Mountain	0.012**	0.013**	0.001	0.002
	(0.002)	(0.002)	(0.006)	(0.006)
Forest	0.007	0.006	0.000	-0.001
	(0.006)	(0.006)	(0.008)	(0.007)
Asphalt road	-0.013**	-0.014**	0.000	-0.001
	(0.003)	(0.002)	(0.007)	(0.007)
Log population	0.006**	0.006**	0.017**	0.017**
	(0.002)	(0.001)	(0.006)	(0.006)
Constant	0.223**	0.163**	0.194**	0.126**
	(0.010)	(0.010)	(0.030)	(0.027)
R2	0.353	0.400	0.287	0.333
Observations	11540	11540	11540	11540

Notes: Dependent variable in OLS and 2SLS regressions is male and female literacy gap (1996). Regressions are district-level fixed effect. Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$.

Table 14: DID estimates of the impact of exposure to electricity on fertility

	(1)	(2)	(3)
Program village	-0.037**	-0.010*	-0.000
	(0.004)	(0.005)	(0.004)
Time trend	-0.368**	-0.368**	-0.368**
	(0.005)	(0.005)	(0.004)
Program effect	-0.064**	-0.064**	-0.064**
	(0.006)	(0.006)	(0.005)
TV exposure		-0.022**	-0.011**
		(0.004)	(0.004)
Village had in 1986			
Primary school		-0.032**	-0.030**
		(0.006)	(0.006)
Middle school		-0.083**	-0.059**
		(0.005)	(0.004)
High school		-0.037**	-0.013
		(0.011)	(0.010)
Mosque		-0.096**	-0.039**
		(0.003)	(0.004)
Shia majority		-0.054**	-0.038**
		(0.003)	(0.004)
Village geography			
Mountain		-0.004	-0.004
		(0.003)	(0.003)
Forest		-0.082**	-0.022*
		(0.011)	(0.009)
Asphalt road		-0.004	-0.011**
		(0.003)	(0.003)
Log population		0.032**	0.023**
		(0.002)	(0.002)
Health house coverage		-0.008**	
		(0.002)	
Constant	1.020**	1.005**	0.974**
	(0.003)	(0.013)	(0.013)
R^2	0.499	0.534	0.602
Observations	25188	25188	25188

Notes: Column 3 is district-level fixed effects. TV exposure is a binary variable indicating availability of TV signal in the village in 1996. Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$.

Table 15: Propensity score matching estimates of the impact of access to electricity on fertility

Variable	Sample	Treated	Controls	Difference	S.E.
Change in CWR 1986-1996	Unmatched	-0.433	-0.368	-0.064	0.005
	ATT	-0.433	-0.403	-0.029	0.010

Table 16: IV estimates of the impact of exposure to electricity on fertility (Controlling for CWR 1986)

	OLS		2SLS	
Electricity exposure 96	-0.003**	-0.002**	0.014**	0.009**
	(0.000)	(0.000)	(0.004)	(0.003)
Child-woman ratio 1986		0.213**		0.244**
		(0.007)		(0.011)
Primary school exposure 96	-0.002**	-0.001**	-0.003**	-0.002**
	(0.000)	(0.000)	(0.000)	(0.000)
Middle school exposure 96	-0.003**	-0.002**	-0.004**	-0.003**
	(0.000)	(0.000)	(0.000)	(0.000)
High school exposure 96	0.001**	0.001**	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
TV exposure 96	-0.034**	-0.036**	-0.091**	-0.074**
	(0.005)	(0.005)	(0.014)	(0.012)
Village had in 1986				
Mosque	-0.037**	-0.031**	-0.049**	-0.038**
	(0.005)	(0.005)	(0.006)	(0.005)
Shia majority	-0.017**	-0.014*	-0.019**	-0.015*
	(0.006)	(0.006)	(0.006)	(0.006)
Village geography				
Mountain	-0.008**	-0.004	0.022**	0.017**
	(0.003)	(0.003)	(0.007)	(0.006)
Forest	-0.017*	-0.013	-0.001	-0.002
	(0.009)	(0.008)	(0.011)	(0.010)
Asphalt road	-0.019**	-0.017**	-0.051**	-0.038**
	(0.003)	(0.003)	(0.008)	(0.007)
Log population	0.014**	0.002	-0.016*	-0.020**
	(0.002)	(0.002)	(0.007)	(0.006)
Constant	0.607**	0.436**	0.734**	0.499**
	(0.013)	(0.014)	(0.038)	(0.028)
R2	0.379	0.428	0.179	0.343
Observations	14416	14416	14416	14416

Notes: Dependent variable in OLS and 2SLS regressions is child-woman ratio (1996). Regressions are district-level fixed effect. Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$.

Table 17: First stage regressions

	(1)	(2)
Elevation	-1.298**	-1.770**
	(0.172)	(0.173)
Primary school exposure 96	0.046**	0.045**
	(0.007)	(0.006)
Middle school exposure 96	0.103**	0.088**
	(0.008)	(0.009)
High school exposure 96		0.041**
		(0.013)
TV exposure	3.673**	3.186**
	(0.176)	(0.133)
Village had in 1986		
Mosque	0.641**	0.772**
	(0.165)	(0.146)
Shia majority	0.337	0.181
	(0.209)	(0.175)
Village geography		
Mountain	-1.363**	-1.371**
	(0.119)	(0.107)
Forest	-0.990*	-0.890*
	(0.391)	(0.349)
Asphalt road	1.911**	1.788**
	(0.121)	(0.106)
Log population	1.722**	1.768**
	(0.081)	(0.074)
Constant	-5.688**	-5.076**
	(0.794)	(0.709)
R2	0.462	0.502
Observations	11540	14416
F-statistics	306.54	97.15

Notes: Dependent variable in the first-stage regressions is years of exposure to electricity till 1996. Column 1 regression is run on the literacy sample and column 2 on the fertility sample. Regressions are district-level fixed effect. Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$.