Rural electrification and female empowerment in Iran: decline in fertility and rise of literacy[*]

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Abstract

We examine the impact of the rapid expansion of electricity to rural areas of Iran after the 1979 revolution on two important determinants of women's empowerment, fertility and literacy. We use the timing of provision of electricity to villages to identify its impact on the child-woman ratio and the literacy rate of adult women. We use a difference-in-difference method as well as instrumental variables to account for the potential endogeneity of electrification. Our findings for the impact of electricity on fertility is highly sensitive to the method of identification. The DID framework suggests that electrification lowers fertility whereas the IV estimates suggest the opposite. The results on literacy are unanimous in showing a positive effect from electrification on female literacy.

[*].

1 Introduction

It is widely acknowledged that good public infrastructure is essential for economic development. The value of good roads and reliable electricity supply for business investments is well established. A growing literature is asking how specific services, such as roads, electricity, clean water, and communications services affect economic growth (Agenor and Moreno-Dodson 2006; Canning and Pedroni 1999b; Canning and Pedroni 1999a; Barnes 1988; Barkat, Khan, Rahman, Zaman, Poddar, Halim, Ratna, Majid, Maksud, Karim, et al. 2002; Fluitman 1983; Henderson, Storeygard, and Weil 2011; Merrick 1985). Such information is essential for allocation of limited public funds for investment in infrastructure. An important channel through which infrastructure promotes economic development is by changing the behavior of families, an area that has been less explored.

Recent theories of development place great emphasis on the family as an agent of economic growth. Theories of Becker (1992), Lucas (2002), and others, sometimes known as the unified growth theory (Galor 2004), pay particular attention to the behavior of families in fertility and investment in human capital. The model by Lucas, for example, links Industrial Revolution to the emergence of technologies that increase the returns to human capital and induce families to have fewer children and invest more in the education of their children. At the heart of these theories is change in the behavior of women that one can characterize as greater empowerment: moving away from traditional roles in procreation and house work to new roles in market work and the production of human capital at home.

In this paper we take up the question of how the extension of electricity to rural areas of Iran have affected the fertility and literacy of rural women, two of the most important components of empowerment. The study of women's empowerment in Iran raises interesting issues because the Islamic revolution of 1979 brought with it two seemingly opposed objectives. A strong conservative current wanted to promote the role of women as mothers and homemakers and strongly advocated large families. Another current, championed populist development policies, especially in rural areas, which revolutionaries believed had been neglected by the Pahlavi regime they had overthrown(Salehi-Isfahani 2009). The populist streak lost no time in getting on with rural development, with rural electrification as its banner program. During its first ten years (1978-1988), despite a devastating war that raged for 8 of the ten years, it raised the percentage of rural families with electricity from 22.6% to 68.5%, and in its second decade to 93.7% (Statistical Center of Iran, Expenditures and Income Surveys, various years, http://amar.sci.org.ir).

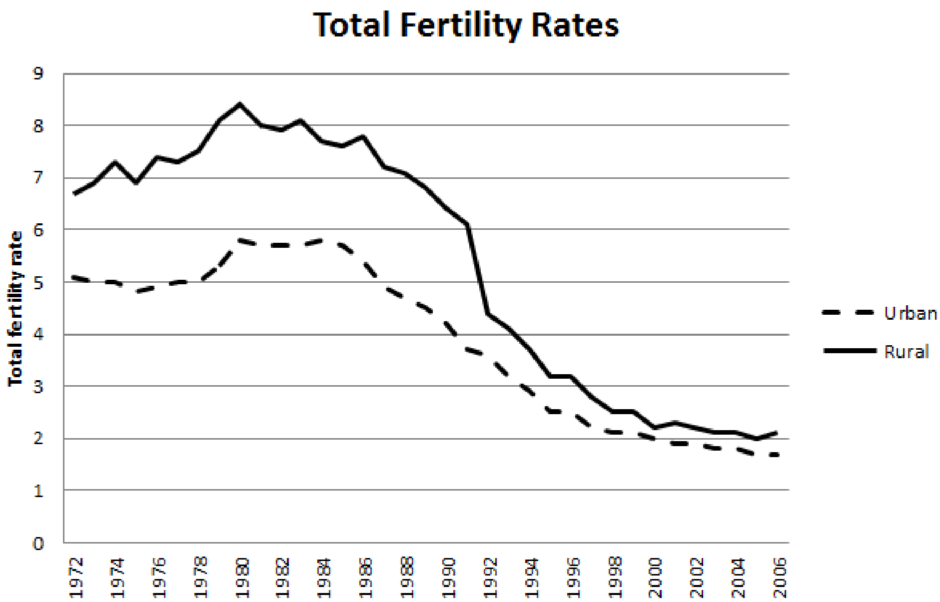
Another policy, seemingly contradictory with the conservative Islamic view of women's status in society, was its active promotion of family planning in rural areas, starting in 1989 (Abbasi-Shavazi, McDonald, and Hosseini-Chavoshi 2009),(Salehi-Isfahani, Abbasi-Shavazi, and Hosseini-Chavoshi 2010). (The leadership of Islamic Republic has now come to regret this particular policy and the government has passed legislation undoing the incentives for smaller families.)

The contradictory objectives of the revolutionaries not withstanding, life for rural women improved considerable in the first two decades of the Islamic Republic. Fertility dropped from above 7 birth per woman to just 2 in a period of 15 years (see Figure 1). Rural literacy improved significantly. In 1978, 35.6% of rural households did not have any literate members; by 1988, it had dropped to 22.5% and by 1998 to 12.1%. The education of rural women seems to have improved even more. The average woman born in the 1960s would have about 1.5 years of schooling by the time she reached adulthood; those born a generation later, in the 1980s, would have about 8 years (see Figure 2).

In this paper we examine the role of rural electrification on rural fertility and female literacy. More specifically, we try to quantify the impact of the extension of electricity to rural areas on village-level child woman-ratios and female literacy rates. We exploit the timing of extension of electricity to rural areas to identify this impact. Since allocation of electricity to villages is in principle not completely random, we employ different strategies to deal with the potential endogeneity of program placement. We first use the difference in differences (DID) method to account for endogeneity under the assumption that conditional on certain village characteristics, placement of electricity was exogenous. We define a control group as those villages without electricity in census year 1996 and a treatment group as those that received electricity between 1986 and 1996. DID estimates can be biased if conditioning on village characteristics does not make program placement fully random or if the assumption of "parallel time trends" is violated. The latter assumes that whatever happened to villages without electricity would have happened to those with it had they remained without electricity until 1996. The assumption of conditional independence requires knowing all the variables that influence program placement. We also use instrumental variable (IV) estimation of program impact, which are preferable when such information is incomplete.

We use as instrument village altitude, which is correlated with the cost of electrification and therefore the likelihood of having electricity earlier. The IV results are strikingly different from DID (and OLS) estimates. Whereas DID results suggest that electricity reduces fertility, IV estimates show the opposite. To reconcile

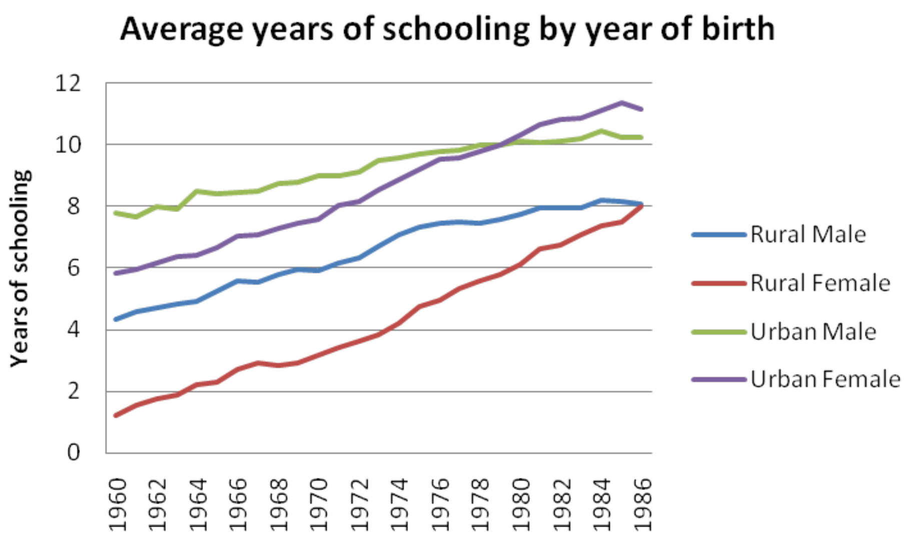
Figure 1: Fertility decline in rural and urban areas



these opposite results one has to assume that DID estimates are biased downward because electrification is endogenous to the level of development which is correlated with fertility; that is, more developed villages with lower fertility were more likely to have electricity earlier. Removing the bias reveals that the exogenous effect of electrification may well be to *raise* fertility, perhaps through its positive income effect. One would have to assume that any negative price effect on fertility is negligible relative to the positive income effect. This is plausible because rural women in Iran either do not engage in market work or when they do they work at home, which is less in competition with childcare. Our DID and IV results for the impact of electrification on female literacy are all in the same direction, indicating that electrification increases female literacy.

Our analysis focuses on the period before 1996 during which major changes took place in provision of electricity as well as in fertility and literacy. By the time of the next census, 2006, the variation in CWR is much lower because fertility transition had extended to the entire rural population. In 1996 more than 50% of villages in our sample had CWRs greater than 0.5 (about TFR greater than 3), whereas in 2006 only 3% had where in that category. A similar convergence in literacy rates reduces the precision with which we can estimate the impact of electricity on female literacy.

Figure 2: Average years of shcooling by birth year



2 Conceptual framework

Rural electrification can affect fertility in two ways, through its impact on farm and home production, and through general socioeconomic changes (Cornwell and Robinson 1988). Electrification provides access to new forms of home and farm labor-saving technologies. However, it is not theoretically obvious whether improvement in the efficiency of home and farm production, increases or decreases fertility. The answer may depend on whether children represent an old age security asset or not, the price of new technologies, and other factors. According to Pollak and Wachter (1975) the shadow price of home production is determined by the technology which is used to produce them. Therefore, rural electrification may have important implications for the relative value of womens time working outside the home. In the standard model of Gronau (1977), women would spend more time on home production if it becomes more efficient. If children are consumption goods, their shadow price would decrease with more efficient home production technology. Therefore, fertility would increase as a result of introduction of new technologies to households.

On the other hand, in poor countries, where home production is not efficient and children are considered investment goods, improvement in home production technology may have a different effect than in developed countries (Grogan and Sadanand 2009). Electricity-based technologies would enhance both farm and home production while using less labor. This, in turn, would reduce the dependence on family labor and the economic value of children. In this case, electrification could be expected to reduce fertility.

Because in theory the effect of electrification on fertility is ambiguous, it is an empirical question. Existing empirical studies provide mixed evidence on this relationship. Cornwell and Robinson (1988) evaluate the effects electrification on rural fertility in the US and find that electrification reduces fertility in Southern counties, but is positively associated with fertility in richer non-southern counties. Greenwood, Seshadri, and Yorukoglu (2005) explain the baby boom in the US as a result of entering electric appliances to homes. In contrast, Bailey and Collins (2011) conclude a negative association between fertility and the extent to which women have access to electricity and appliances during their reproductive year.Peters and Vance (2011) find a positive relationship between fertility and electricity for urban households contrasted by a negative association for rural households.

Most of the early studies of the relatiosnhip between electrification and fertility were not concerned with causality. Grogan (2011) attempted to identify the causal impact of household electrification status on birth propensities of women employing recursive bivariate Probit model. She uses the information on the historical development level (literacy rate) of the main town in a Colombian municipality and topographical information (slop gradient of land) to proxy the relative cost of extending the grid from town to rural areas. These variables then are used to identify the probability that a household has electricity. Grogans paper demonstrates that household electrification causes a reduction in yearly birth propensities of about 6 percent.

Dinkelman (2011) also accounts for endogeniety of the placement of infrastructures to determine the causal impact of rural electrification on employment effects in South Africa. This study also uses the land gradient, which affects the cost of electricity grid expansion, as an instrument for project placement. Grogan and Sadanand (2012) uses two proxies for the cost of electrification, population density and the mean slop gradient to identify the impact of electrification on labor supply of adults. Lipscomb, Mobarak, and Barham (2013) estimate the development effect of electrification by taking geographic inputs, i.e. river gradient, water flow, and Amazon into their engineering model and construct a time series of hypothetical electricity grids.

Our study contributes to the literature of the impact of rural electrification by defining an instrumental variable which measure the difference in altitude between each village and the district's main city.

3 Data

Our unit of observation is the village. For each village we have information on the year in which it received electricity, its child-woman ratio and the rate of literacy of its women 15-49 years old. Most of our data come from various censuses of population. 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. The census years 1986 and 1996 are chosen since the data on village child-woman ratio (fertility) and female literacy rate can only be employed from census data source. Data also consists of information on availability of schools (primary, secondary and high school), religion characteristics (availability of mosque and whether village has Shia majority), village population in the year 1986, topographical information (whether the village is located on the plain, forest or mountain area), and quality of the village roads to the towns for the year 2006.

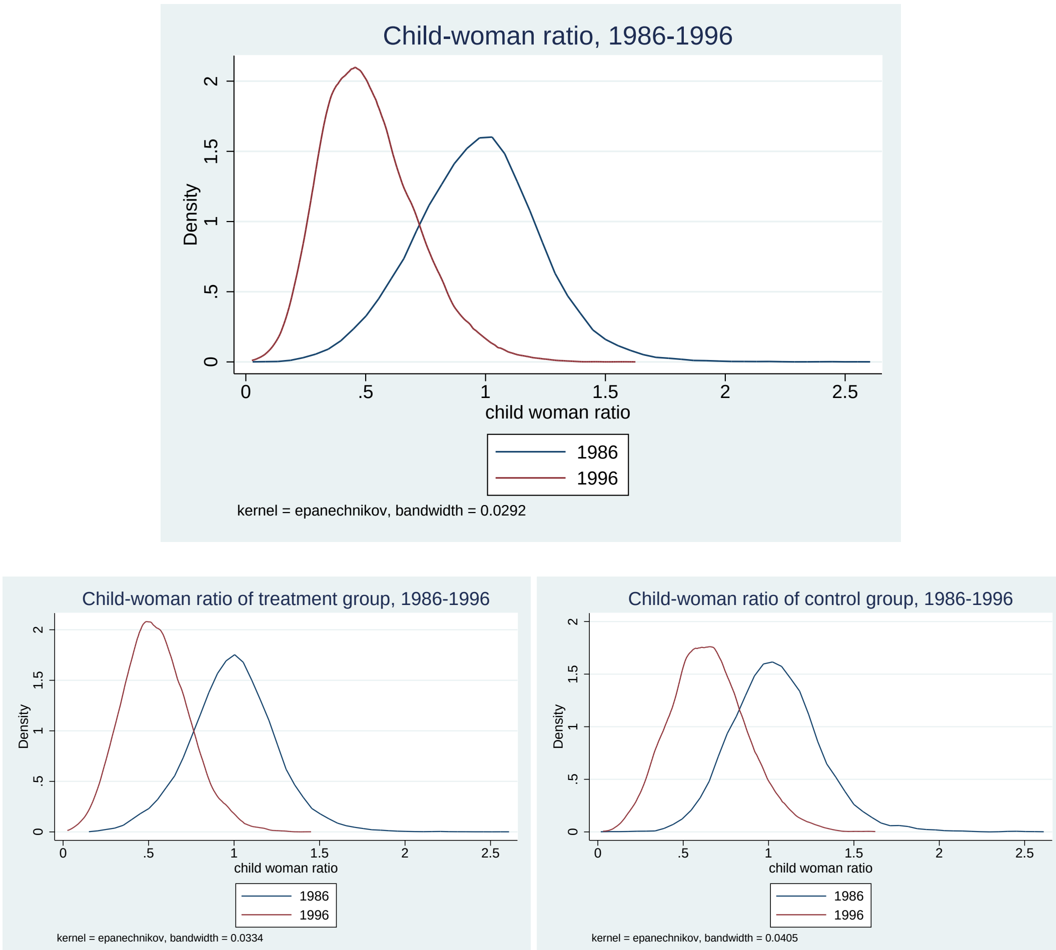
The 2006 census counted approximately 120,000 villages in Iran, many of which are hamlets and small settlements. We exclude villages with fewer than 100 people because their CWR are highly dependent on the age structure of their population, which may have shifted due to migration rather than change in fertility behavior.

Village fertility is measured using the child-woman ratio (CWR). The village CWR is the ratio of children less than 5 years of age to rural women aged 15 to 49. In addition, the outliers are eliminated by dropping villages with CWR less than 2 children or more than 1500 children per 1000 women.

For the DID estimation we need to 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. As a result we lose 13,090 (and 11,980) villages that had electricity by 1986 in cwr (and literacy) estimations .

The sample for IV estimation relies on the earliest year in which a village was listed as having electricity. This is not necessarily the year that it first had electricity, because the Ministry of Agriculture 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 as exogenouse variation in the cost of extending rural electricity. The data on elevation of villages has been collected by hand from the website of National Cartographic Center of Iran (http://www.ncc.org.ir). Since this data is collected from a public source, the sample is limited to 24625 villages for 30 provinces. Merging the data set of village elevation with sample of villages con-

Figure 3: Child-woman ratio by treatment status



taining facilities and demographic characteristics decreases our village observations to about 13,800 and 11,900 villages, respectively in fertility and literacy estimations of electrification impact.

Furthermore, the samples for fertility and literacy impact evaluations are also not the same because of the way data from different sources merge. Tables 1 and 2 provide summary statistics for the four samples, two for each dependent variable, CWR and literacy.

The village level data capture well the changes in fertility and literacy over the 1986-1996 period. The figures show the distribution of child-woman ratio and female literacy rate by treatment status.

Table 1: Summary statistics for DID and IV estimations of CWR

	Full sample		Control		Program	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Child-woman ratio 86	1.00	0.22	1.02	0.22	0.98	0.22
Child-woman ratio 96	0.58	0.20	0.65	0.22	0.55	0.18
Village population	385.91	341.47	285.87	245.75	433.08	369.01
Proportion of villages with						
Primary school	0.93	0.26	0.88	0.33	0.95	0.21
Middle school	0.08	0.28	0.04	0.18	0.11	0.31
High school	0.01	0.11	0.00	0.07	0.02	0.13
Mosque	0.77	0.42	0.70	0.46	0.81	0.39
Shia majority	0.76	0.42	0.68	0.47	0.81	0.40
Asphalt road	0.42	0.49	0.19	0.39	0.53	0.50
Village geography						
Plain	0.29	0.45	0.16	0.37	0.35	0.48
Mountain	0.70	0.46	0.83	0.37	0.64	0.48
Forest	0.02	0.12	0.01	0.10	0.02	0.14
No. of observations	13353		4279		9074	

Summary statistics for OLS and IV sample

	Mean	Std. Dev.	Min	Max
Child-woman ratio 86	0.96	0.23	0.20	1.50
Child-woman ratio 96	0.50	0.17	0.20	1.36
Village population	600.68	599.16	100	7545
Electricity exposure 96	9.17	6.66	0	30
Elevation	1.33	0.67	-0.03	2.95
Elevation difference	0.08	0.36	-1.66	2.27
Proportion of villages with				
Primary school	0.97	0.18	0	1
Middle school	0.21	0.41	0	1
High school	0.05	0.22	0	1
Mosque	0.83	0.38	0	1
Shia majority	0.89	0.31	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	0.01	0.12	0	1
No. of observations	13783			

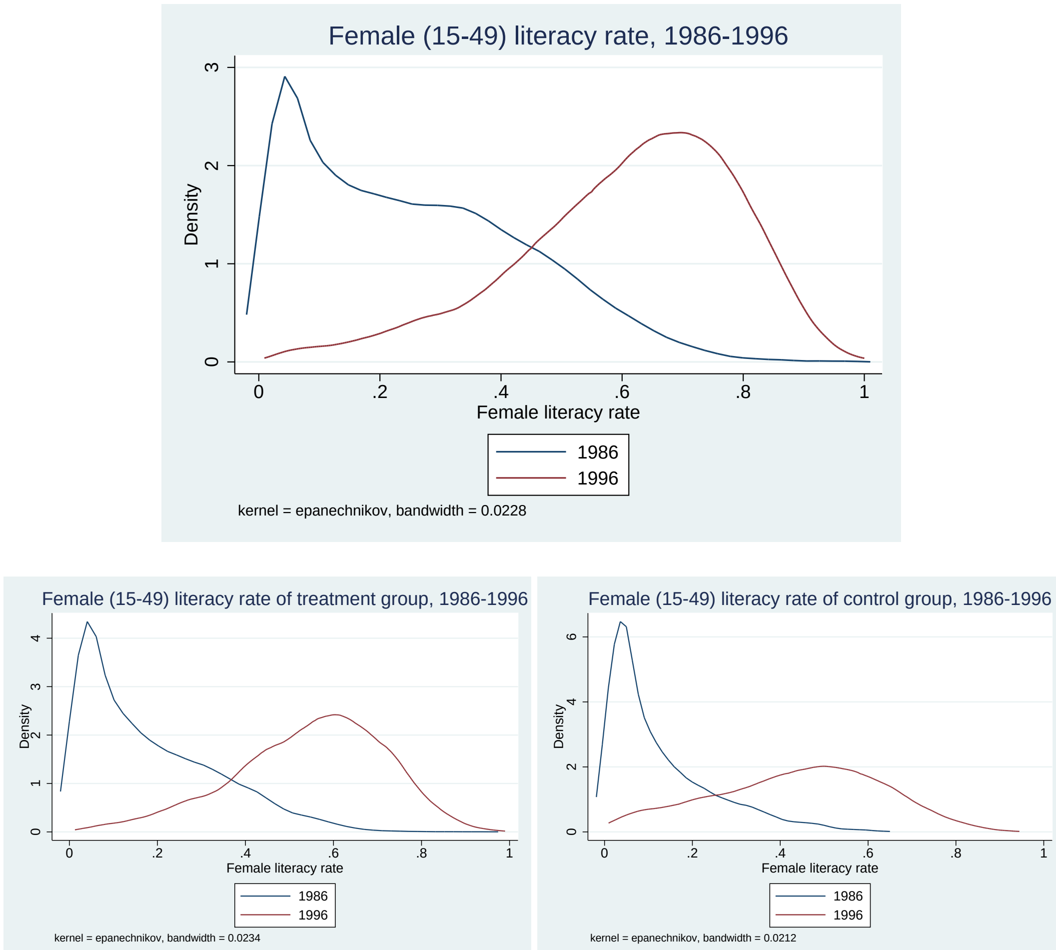
Table 2: Summary statistics for DID and IV estimations of literacy

	Full sample		Control		Program	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Female literacy rate 86	0.17	0.15	0.13	0.12	0.18	0.15
Female literacy rate 96	0.52	0.18	0.44	0.19	0.55	0.17
Village population	420.08	360.22	319.65	297.94	454.03	372.92
Proportion of villages with						
Primary school	0.96	0.20	0.94	0.24	0.96	0.19
Middle school	0.11	0.31	0.06	0.23	0.13	0.34
High school	0.02	0.13	0.01	0.08	0.02	0.14
Mosque	0.78	0.41	0.70	0.46	0.81	0.39
Shia majority	0.85	0.36	0.78	0.41	0.87	0.34
Asphalt road	0.49	0.50	0.23	0.42	0.58	0.49
Village geography						
Plain	0.32	0.47	0.19	0.39	0.37	0.48
Mountain	0.66	0.47	0.80	0.40	0.61	0.49
Forest	0.02	0.13	0.01	0.09	0.02	0.15
No. of observations	9186		2321		6865	

Summary statistics for OLS and IV sample

	Mean	Std. Dev.	Min	Max
Female literacy rate 86	0.28	0.18	0.00	0.96
Female literacy rate 96	0.62	0.18	0.01	1
Village population	607.07	585.32	100	6251
Electricity exposure 96	9.61	6.64	0	30
Elevation	1.28	0.69	-0.03	2.95
Elevation difference	0.08	0.38	-2.834	2.265
Proportion of villages with				
Primary school	0.97	0.18	0	1
Middle school	0.22	0.42	0	1
High school	0.06	0.23	0	1
Mosque	0.82	0.39	0	1
Shia majority	0.93	0.26	0	1
Asphalt road	0.69	0.46	0	1
Village geography				
Plain	0.52	0.50	0	1
Mountain	0.47	0.50	0	1
Forest	0.02	0.12	0	1
No. of observations	11919			

Figure 4: Literacy rates by treatment status



4 Methodology

We use the timing of village electrification in two ways. In one method, we set up the impact evaluation problem within a difference-in-differences framework in which treatment is to have received electricity in a ten year interval (1986-1996). The second method is to define the intensity of treatment by the number of years a village has been "exposed" to electricity. The latter formulation allows us to deals with the potential endogeneity of program placement by using an instrument – village altitude – which we assume is correlated with the the timing of the extension of electricity but not directly correlated with fertility or literacy.

4.1 Difference in differences

The DID estimator assumes that the underlying average trend in the outcome of interest is the same for treated and untreated groups of villages, so that any difference between the two can be attributed to treatment.

The following formulation of the DID estimator, which closely follows those in (Wagstaff et al. 2009) and (Salehi-Isfahani, Abbasi-Shavazi, and Hosseini-Chavoshi 2010), relates village-level 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 fertility in village i in year t= 1986 and 1996, H_{it} is fertility decline due to the presence of electricity, X_{it} are a vector of observable village characteristics that influence fertility, 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 fertility between 1986 and 1996 for each group helps eliminate the μ's (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:

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

The simplest formulations of DID omit X's from 1 (as in Wooldridge (2002)). In our case the X's only have the 1986 values, so they are eliminated in the first differencing. Some of the X's, such a religion variables, simply do not change while other influence fertility only slowly, so we keep them in the DID regressions below because they influence not just the level but also the trends in fertility. In other words, we assume that the parallel trends assumption $\Delta\theta^P - \Delta\theta^C = 0$ holds conditional on observable village characteristics. Thus we condition on these characteristics in the DID regressions.

The DID regression takes the usual 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 of village i in year t, D is a dummy variable which takes the value of one if the village has a electricity in year t, $Year = 1$ if 1996 and zero otherwise. The value of β is the estimate of the difference 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, which in fact occurred continuously during 1986-96, is an approximation forced on us by the fact that we observe village level fertility only in census years 1986 and 1996. It may be argued that villages with electricity, say, in 1995 should be counted in the comparison group. We examine the sensitivity of our results to how we define being treated by taking out the villages with short duration from the program group. 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. Again, our results do not change when we define treatment differently.

4.2 Instrumental variables

We model fertility and literacy rates of a village as a function of its exposure to electricity and other village characteristics in 1986, the first year for which we have a complete set of such characteristics.

$$Y_{it'} = \alpha + \beta E_i + X_{it}\psi + \epsilon_i \tag{3}$$

where t' is 1996 or 2006, and E_i is the number of years of exposure by the time of observation in 1996, and X_{it} are a set of village characteristics in the base year, 1986. The IV estimation uses altitude as an instrument for E.

5 Results

5.1 DID

We first examine the impact of electrification in a quasi experimental method. Our program (treatment) group are villages that did not have electricity in 1986 and the comparison (control) group consists of those that received electricity sometime during 1986-96. Table 3 presents the results in 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 per 1000 and the difference between the program and comparison groups is 34 per 1000. The program effects estimated at 65 per 1000. Adding the controls in column 2 reduces the difference in cwr between the two groups to 5 per 1000, which indicates our conditioning is effective. The common time trend and the program effect do not change. The last column controls for district-level fixed effects and the initial gap in fertility between the program and comparison groups falls to only 2 per 1000.

The IV estimates are presented in Table 4 using the years of exposure to electricity as treatment. Column 1 is the OLS result showing the impact of exposure at 5 per 100 per year. So, if we do not consider placement of electricity as endogenous, for a 10 year period comparable to the DID estimates of impact, electricity would reduce fertility by 50 per 1000, which is slightly under the 65/1000 we found with DID. Column 2 and 3 use an instrument – the difference between village elevation and the district center – and finds the opposite result: In column 3, the program impact is to add 20 children per 1000 women. This result is theoretically plausible given the ambiguity we noted earlier in Section 2.[1] The first stage results in column 1 show that our instrument is valid because it is negatively related to the timing of electrification and passes the Hausmann test.

Moving to literacy, DID and IV estimates presented in Tables 5 and 6. As with fertility, the estimates of program impact – 51 per 1000 – remain unchanged as we add controls and fixed effects. However, unlike fertility, the difference between program and comparison villages stays relatively large as we add controls (falling from 51 to 35 per 1000). This indicated that program endogeneity is perhaps more severe in the case of literacy. The IV estimates suggest an increase of 20/100 per year, which is much higher than the 35 per 10 years estimated by DID. Again the first stage estimates are highly plausible and indicate the the instrument is valid.

6 Conclusions

In this paper we have found evidence that, as theory would suggest, electrification had an unambiguously positive effect on female literacy. We find that controlling

[1]The estimates of impact on fertility maybe too high in DID compared to exposure because binary designation of treatments that vary in intensity tend to be higher (Angrist and Imbens 1995).

Table 3: DID estimates of the impact of exposure to electricity on fertility

	(1)	(2)	(3)
Program village	-0.034**	-0.005	-0.002
	(0.004)	(0.004)	(0.004)
Time trend	-0.368**	-0.368**	-0.368**
	(0.005)	(0.004)	(0.004)
Program effect	-0.065**	-0.065**	-0.065**
	(0.005)	(0.005)	(0.005)
Village had in 1986			
Primary school		-0.031**	-0.027**
		(0.005)	(0.005)
Middle school		-0.064**	-0.060**
		(0.005)	(0.005)
High school		-0.070**	-0.049**
		(0.011)	(0.011)
Mosque		-0.041**	-0.038**
		(0.004)	(0.004)
Shia majority		-0.044**	-0.036**
		(0.004)	(0.004)
Village geography			
Mountain		0.001	-0.002
		(0.003)	(0.003)
Forest		-0.020*	-0.022*
		(0.010)	(0.010)
Asphalt road		-0.013**	-0.011**
		(0.003)	(0.003)
Log population		0.025**	0.023**
		(0.002)	(0.002)
Constant	1.018**	0.907**	0.957**
	(0.003)	(0.015)	(0.012)
R2	0.502	0.580	0.608
Observations	26706	26706	26706

Notes: Column 2 includes dummy variables for provinces and column 3 is district-level fixed effects. All school and religion characteristics are 1986 variables. Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$.

Table 4: IV estimates of the impact of exposure to electricity on fertility

	OLS	first-stage	2SLS
Log elevation difference		-0.101**	
		(0.019)	
Electricity exposure	-0.005**		0.020**
	(0.000)		(0.007)
Village had in 1986			
Primary school	-0.045**	0.358	-0.054**
	(0.010)	(0.232)	(0.012)
Middle school	-0.057**	1.525**	-0.095**
	(0.003)	(0.150)	(0.012)
High school	-0.055**	3.225**	-0.137**
	(0.005)	(0.270)	(0.025)
Mosque	-0.077**	0.816**	-0.097**
	(0.004)	(0.122)	(0.008)
Shia majority	-0.090**	0.584**	-0.105**
	(0.005)	(0.143)	(0.007)
Village geography			
Mountain	0.007*	-2.537**	0.077**
	(0.003)	(0.109)	(0.021)
Forest	-0.063**	-1.195**	-0.030
	(0.011)	(0.414)	(0.018)
Asphalt road	-0.027**	3.298**	-0.111**
	(0.003)	(0.110)	(0.025)
Log population	0.020**	1.937**	-0.029
	(0.002)	(0.078)	(0.015)
Constant	0.640**	-5.908**	0.777**
	(0.015)	(0.466)	(0.045)
R2	0.181	0.339	
Observations	13783	13783	13783

Notes: All school and religion characteristics are 1986 variables. Standard errors in parentheses,* $p < 0.05$, ** $p < 0.01$.

Table 5: DID estimates of the impact of exposure to electricity on female literacy

	(1)	(2)	(3)
Program village	0.056**	0.036**	0.035**
	(0.004)	(0.003)	(0.003)
Time trend	0.313**	0.313**	0.313**
	(0.005)	(0.004)	(0.004)
Program effect	0.051**	0.051**	0.051**
	(0.005)	(0.004)	(0.004)
Village had in 1986			
Primary school		0.030**	0.031**
		(0.005)	(0.005)
Middle school		0.070**	0.055**
		(0.003)	(0.003)
High school		0.082**	0.062**
		(0.008)	(0.007)
Mosque		0.032**	0.041**
		(0.003)	(0.003)
Shia majority		0.070**	0.051**
		(0.003)	(0.003)
Village geography			
Mountain		-0.018**	-0.024**
		(0.002)	(0.002)
Forest		-0.022**	-0.026**
		(0.008)	(0.007)
Asphalt road		0.036**	0.030**
		(0.002)	(0.002)
Log population		-0.037**	-0.028**
		(0.002)	(0.002)
Constant	0.127**	0.231**	0.195**
	(0.003)	(0.013)	(0.010)
R2	0.551	0.699	0.737
Observations	18372	18372	18372

Notes: Column 2 includes dummy variables for provinces and column 3 is district-level fixed effects. All school and religion village characteristics are 1986 variables. Standard errors in parentheses,* $p < 0.05$, ** $p < 0.01$.

Table 6: IV estimates of the impact of exposure to electricity on female literacy

	OLS	first-stage	2SLS
Log elevation difference		-0.094**	
		(0.021)	
Electricity exposure	0.009**		0.020**
	(0.000)		(0.006)
Village had in 1986			
Primary school	0.074**	0.169	0.072**
	(0.010)	(0.252)	(0.010)
Middle school	0.050**	1.475**	0.035**
	(0.003)	(0.154)	(0.010)
High school	0.043**	3.249**	0.008
	(0.005)	(0.267)	(0.021)
Mosque	0.095**	0.970**	0.085**
	(0.004)	(0.130)	(0.007)
Shia majority	0.121**	0.733**	0.113**
	(0.007)	(0.181)	(0.008)
Village geography			
Mountain	-0.049**	-2.539**	-0.019
	(0.003)	(0.117)	(0.018)
Forest	0.023*	-1.112*	0.036*
	(0.011)	(0.451)	(0.014)
Asphalt road	0.061**	3.400**	0.024
	(0.003)	(0.120)	(0.022)
Log population	-0.034**	1.828**	-0.054**
	(0.002)	(0.083)	(0.012)
Constant	0.442**	-5.181**	0.494**
	(0.015)	(0.507)	(0.034)
R2	0.384	0.326	0.279
Observations	11919	11919	11919

Notes: All school and religion characteristics are 1986 variables. Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$.

for endogeneity of program placement, the impact is four times as large. Our DID and IV estimates of impact on fertility diverge. The IV estimates suggest the causal impact of electrification may have been to increase fertility, an outcome that is also theoretically plausible.

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