Sparking Fertility: The Rural Electrification Administration and Fertility in the United States 1930-1940

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Abstract

Are children normal goods? This paper examines this question by examining a productivity shock associated with the introduction of electricity via the Rural Electrification Administration (REA). Theoretically, the demand for children may rise or fall due to both quantity-quality tradeoffs and substitution between farm inputs. To identify the effect of REA electrification on fertility, I construct a panel of county level fertility rates and use variation in the cost of wholesale service to account for the selection of REA project areas. I find that the REA led to large increases in fertility during a period of secular decline in fertility and this is robust to a variety of other programs targeted at agriculture and electrification. I then discuss some of the mechanisms which would lead to increased fertility during this period and provide reasons why these results differ from most studies that have examined the relationship between fertility and electrification.

1. Introduction

Ever since Gary Becker's seminal work on family choice, empirical researchers have searched for evidence to determine if children are normal or inferior goods. Research on this topic has provided mixed evidence, cross county and time series regressions have hinted at a negative correlation between fertility and income, however, these correlations are not evidence of a causal relationship. More recently, there has been a set of papers seeking to link the causal relationship between changes in income and fertility. This research has tended to find that children are in fact normal for shocks to male income. Lindo (2010), Black, Kolesnikova, Sanders, Taylor (2011), Lovenheim and Mumford (2011), and Dettling and Kearney (2011) all show that the likelihood of having a child rises when there is a perceived permanent income shock to the family, whether it is due to job displacement, energy price shocks impacting certain types of employment, or shocks to housing values for owners.

While these recent papers have provided evidence that children are normal under these various contexts, there is an existing literature in development that seeks to correlate the impacts of infrastructure and technology improvements on demographic transitions. Specifically, researchers have been interested in the connection between the rollout of electrification and fertility. Thus far the research has generally shown a negative relationship between the two. Bailey and Collins (2009) model the effects of fertility and show that theoretically electrification may either increase child quality while decreasing quantity or increase quantity. In their empirical work they show in state level regressions that fertility is negatively associated with electrification. They also show that groups who did not experience electrification, such as Old Order Amish, had similar fertility patterns as the rest of the nation throughout the Baby Boom.

Several other studies (Harbison and Robinson 1985, Cornwall and Robinson 1988, Lewis 2012) have found similar correlations.

While these studies have generally found a negative correlation between electrification and fertility several issues exist in each of these studies which may bias their coefficients. First and foremost, electrification most often occurs in urban areas and historic manufacturing centers first, where labor market opportunities are the best for women. If women substitute away from the home and towards labor, the correlation would suggest that electrification decreases fertility. Additionally, electrification may be changing the opportunities for women outside the home; therefore, these papers likely identify the substitution effect of women when the female labor market opportunities improve over time. Some evidence of this effect can be seen in work by Dinkelman (2011) who documents the improvements in female labor market conditions when electrification was rolled out in South Africa following Apartheid. Prior research has also tended to focus on the gradual expansion of electricity; however, if large nonlinearities exist in the effects of electrification on fertility, it may be important to study the effects when electricity is first introduced. In samples with urban population this is often difficult to capture as manufacturing sectors began electrifying relatively earlier than households which would have already altered labor market opportunities before the arrival of electricity in the home.

In this paper I address both of these concerns by looking at a unique experience in regards to electrification. In 1935, the Rural Electrification Administration (REA) was created by the federal government to provide subsidized loans to groups of rural farmers who wanted to build electric distribution networks in areas that had never been electrified. Electrification was intended to give farmers access to new farm and home technologies in an effort to modernize and mechanize agriculture. Prior to the establishment of the REA only 10 percent of all farms in the

United States were electrified, by 1950, over 90 percent of rural farm households had access to electricity, greatly due to the financing made available by the REA. The REA Loan program was very successful in terms of increasing productivity. Kitchens and Fishback (2012) note that the value of farm products increased by 23-27 percent when a county received an REA electric project. This large rise in farm income associated with REA electrification combined with Great Depression labor market conditions should provide a setting to see what happens to fertility when electricity first arrives.

To determine the impact that REA electrification had on fertility, I use plausibly exogenous variation in the cost of wholesale electric rates, which were a major component of the REA loan application.[1] Using this variation, outcomes in counties with the same a priori probability of being electrified by the REA can be compared to one another. The advantage of this approach is that I am able to account for the endogeneity of electrification, which many other studies have not been able to do in this context. These studies have also typically suffered from measurement error due to within observational unit heterogeneity or omitted variables such as wealth and income that are correlated with the adoption of electricity.

The results from the OLS and IV specifications show that areas that were electrified by the REA experienced increases in fertility between 1930 and 1940. In the OLS specifications, fertility increased by 2.7 percent in areas that received REA electric projects. The IV results, which control for possible endogeneity, suggest that the REA increased fertility by up to 25

[1] In recent independent work, Joshua Lewis (2012) uses the same identification strategy as I will implement, relying on distance from electric generation plants as a proxy for the cost of service. I use the distance in 1935 as my instrument, whereas Lewis uses the change in the distance 1930-1960. During the period after WWII the demand for electricity was expanding rapidly and steam plants were often quickly constructed to meet this demand. Therefore, it is not clear if the implementation of the instrument in Lewis (2012) satisfies the exclusion restriction.

percent. These results are consistent with models that predict improvements in male labor market conditions will lead to increases in fertility.

To help determine if productivity shocks associated with the REA are the driving channel of causality, I examine changes in the input composition following electrification and find no evidence that farmers increased their use of family labor or hired labor, and did not use additional capital inputs. I then further test to ensure that productivity changes are the driving channel of causality by I examine a scenario where electricity was expanded in areas similar to REA locations, but did not increase productivity. To do this, I examine the expansion of electricity under the Tennessee Valley Authority (TVA), which has been shown by Kitchens (2012) to primarily be a public expansion of a pre-existing private network. In this work, it was shown that the TVA did not differentially impact productivity measured by retail sales activity and electricity expanded at similar rates as other areas. Regressions of changes in fertility associated with TVA electrification show that over the same time period, the TVA did not lead to increases in fertility, and exhibits the typical pattern found in prior research. This suggests that for electrification to have a positive impact on fertility there must be a large productivity shock that does not affect female labor market opportunities. This is most likely associated with obtaining electricity for the first time in isolated areas rather than through an expansion of the existing infrastructure.

2. The Rural Electrification Administration and the Diffusion of Technology

During the first half of the 20th century there were rapid advances in the use of household technology and electricity. Household electrification became commonplace, by 1950, almost every home in the United States had electricity. Even prior to electrification there was a diffusion of innovation within the home: radios, gasoline powered engines, belt driven washing machines, etc., but with electricity came even more innovation: electric ranges, electric irons, vacuum cleaners, electric water pumps, refrigeration, and eventually air conditioning. By 1960, almost every household had one or more of these devices.

Many urban households began acquiring these devices earlier in the 1920's and some rural areas began acquiring them slightly later. However, while many urban areas experienced electrification in the first quarter of the 20th century, many rural and farm communities could not get connected into the grid. In many cases it was not profitable for private companies to serve rural areas. For every mile of rural line constructed, utilities had to offset construction costs of $1,500-$2,000 per mile of rural line constructed in 1930. A variety of plans were implemented to provide some rural service which typically involved a guaranteed usage per month for a specified time period or some form of cost sharing between the rural customer and utility.[2] Given the large cost of service, many farms remained without central station electric service. In 1930, less than 10 percent of farms were electrified nationwide.

After witnessing the effects of rural electrification in Germany and Nordic countries, members of Congress pushed for financing the expansion of rural electric service in the United States, however change would come through executive action. On May 11, 1935, Executive Order 7037 created the REA and extended the scope of the Emergency Relief Appropriation Act to include rural electrification projects. These programs mandated that labor be hired from relief roles, however, it was realized that the REA required specialized labor that could not be obtained through relief agencies, so in 1936, the REA was established as its own agency. Between 1935

[2] Federal Power Commission Electric Rate Survey. Rural Electric Service. Rate Series No. 8. 1935. P7-8

and 1939, over $227 million ($3.6 billion year 2010) in government subsidized loans were granted for the purposes of rural electrification to newly formed cooperative utilities and existing private utilities that provided rural electricity. By 1939 over 180,000 miles of electric line were either constructed or under construction and over 620,000 farms, or 11 percent of all farms, had been connected to the grid by the REA.[3]

These loans provided funds for the construction of distribution lines, wiring in homes, some working capital for the electric distributors, and in some cases money for the construction of generation plants. The REA loans amortized over 25 years and were designed to be self-liquidating from the revenues from the sale of power. Interest rates were set in accordance with the long term rate on federal funds at time of issue, which during this period ranged from 2.69-3 percent. This amounted to a 3 percent subsidy on a loan, as loans for similar projects, conditional on being able to obtain financing, received rates near 6 percent.[4] To obtain a loan, an organization proposed a plan that included engineering drawings and loan justification. The distributor had to be organized under state law, have secured the necessary property and rights of way, and be in the process of securing a wholesale electric contract.[5]

Under the guidelines of the REA, 50 percent of funds had to be allocated to the states in accordance with the percentage of farms that were not electrified. The remaining 50 percent of funds were allocated based on the discretion of REA administrators such that no state received more than 10 percent of the total REA appropriations in a given year. This gave REA administrators considerable flexibility in the allocation of REA resources which they exercised.

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[3] 1939 REA Annual Report.

[4] Slattery, Harry. Rural America Lights Up. 1940. p52

[5] REA Annual Report 1937 p11-12

REA administrators were very aware that the loans were very risky and that in order for the REA to be a success they had to choose projects that were likely to survive. The administrators noted that one of the major determinates of a cooperatives success was its wholesale power rate, “Sometimes a difference of a fraction of a cent per kilowatt hour in the wholesale rate will represent the difference between a sound and unsound project” (REA Annual Report 1937).[6] While I do not have data on wholesale electric rates for the loan recipients, I know the location of each generation plant in the United States and the location of major transmission lines just prior to the establishment of the REA. Given that transmission is a costly activity, I am able to use the variation in the distance to generation plants and transmission lines as a plausible source of exogenous variation in the allocation of REA loan contracts.

3. The Link Between the REA and Fertility

How would loans from the REA affect the demand for children of farmers? Electricity can affect fertility through both utility maximization and through profit maximization on the farm. For a farmer who jointly maximizes utility subject to farm profits there are multiple effects of electricity on the demand for children as noted by Rosenweig (1977) and are potentially ambiguous in sign. In this section, I present a simple static model of fertility choice in the spirit of Rosenweig (1977) when farm profits compose the budget constraint for a farmer maximizing utility over children and a composite good. This will provide a general framework to think about the different channels through which fertility could be affected by a change in electrification.

The Model

Assume that each farmer has a utility function that satisfies the standard conditions U’>0, U’’<0, and that the utility is derived from the consumption of children and another composite

[6] REA Annual Report 1937 p21

good X. The price of children is *p* and the prize of good *X* is normalized to 1. Therefore the utility is U(C,X) and this is maximized subject to profits of the farm. Farms produce a single output traded in an international market with the price normalized to 1. Production occurs using a child labor input *C*, adult labor L with wage *w*, and energy inputs *E* with price *r*. Production occurs following a production technology defined by *f* which also satisfies standard assumptions, $f' > 0$, $f'' < 0$, its increasing in each argument and has diminishing marginal productivity. I ignore capital as it is unlikely to change in the short run. Farmers maximize their utility by selecting the optimal number of children to have and the optimal level of the other good subject to their budget determined by farm profits. They also select the optimal use of inputs to maximize profits. Therefore, the maximization problem becomes

$$(1)\ Max\ \ U(C,Z) - \lambda\ [pC + X - (f(C, L, E) - wL - rE)]$$

The farmer solves for the optimal inputs and the optimal level of consumption generating the following first order conditions.

$$(2)\ \text{C:}\ \ U_1 - \lambda[p - f_1] \leq 0$$

$$(3)\ \text{X:}\ \ U_2 - \lambda \leq 0$$

$$(4)\ \text{L:}\ \ w - f_2 \leq 0$$

$$(5)\ \text{E:}\ r - f_2 \leq 0$$

$$(6)\ \lambda\text{:}\ \ pC + X - f(C, L, E) + wL + rE \leq 0$$

From these familiar first order equations, it should be apparent from (2) that farmers will consumer a higher numberl of children than their urban counterparts because the marginal productivity of children as a labor input in farm production reduces the cost of having children. As an aside, this is one motivation why we may expect farm families to be larger on average than urban families. From these first order conditions, we may solve for the optimal consumption bundle and optimal input mix as a function of the price of children and input prices, *p, w, r*: *C*(p,w,r), X*(p,w,r), L*(p,w,r), E*(p,w,r) , λ*(p,w,r).*

As previously described, the REA was a program designed to extend electric service to areas that had previously been denied service. The extension of electric service can be viewed as a reduction in the price of energy for farmers. Therefore, to understand the impact of the REA on fertility, we need to examine how the optimal consumption of children changes with a change in the energy price. To obtain his comparative static, I totally differentiate the FOC's at their optimums with respect to a change in energy prices. I assume that both labor and energy are purchased at a price equal to their marginal productivity. I then solve for $\frac{\partial C}{\partial r}$. Totally differentiating and collecting terms yields the following system of equations.

$$\begin{vmatrix} U_{11}+\lambda f_{11} & U_{12} & \lambda f_{12} & \lambda f_{13} & \frac{-U_1}{\lambda} \\ U_{21} & U_{22} & 0 & 0 & \frac{-U_2}{\lambda} \\ -f_{21} & 0 & -f_{22} & -f_{23} & 0 \\ -f_{31} & 0 & -f_{23} & -f_{33} & 0 \\ \frac{U_1}{\lambda} & \frac{U_2}{\lambda} & w-f_2 & r-f_3 & 0 \end{vmatrix} \begin{vmatrix} \frac{\partial C}{\partial r} \\ \frac{\partial X}{\partial r} \\ \frac{\partial L}{\partial r} \\ \frac{\partial E}{\partial r} \\ \frac{\partial \lambda}{\partial r} \end{vmatrix} = \begin{vmatrix} 0 \\ 0 \\ 0 \\ -1 \\ -E \end{vmatrix}$$

Solving for the change in the consumption of children due to a change in the energy price yields the following expression to sign.

$$(7)\ \frac{\partial C}{\partial r}:\ (U_2U_{12} - U_1U_{22}) \geq \frac{U_2^2(f_{22}f_{13} - f_{12}f_{23})}{E[f_{22}f_{33} - {f_{23}}^2]}$$

This simple model shows that the demand for children will change according to two primary factors: increased farm profits due to lower energy input prices, and the substitution between inputs that results from the lower energy prices. Lower input prices lead farmers to produce more output because of the exogenous output price leading to higher profits. Farmers should also substitute towards more energy inputs. Depending on the degree of substitutability between inputs, the optimum number of children could rise or fall. Given the ambiguity of the input relationship, it is difficult to tell whether or not a change in energy prices will result in an increase of decrease in fertility.

While it is not possible to sign the comparative static, this exercise is fruitful because it shows that in agricultural settings, fertility decisions will be impacted by both wealth impacts and changes in the optimal use of inputs. Therefore, any empirical exercise must hope to somehow separate out the productivity and wealth effects to make any stance on the normality of children in an agricultural setting.

4. Data and Empirics

To examine the impact that REA electrification projects had on electrification, I combine several publicly available data sources to construct a panel of county level observations. Data on fertility comes from U.S. Vital Statistics volumes reporting births and female population at the county level. I combine this with other publicly available US Census Volumes that contain population and economic variables made available by Haines (2004). I then merge this with data on REA project locations, which are available in the REA annual reports. To construct the instrument, maps detailing the location of electric generation stations and transmission lines were digitized and geocoded in GIS. These are publicly available via the Federal Power Commission's National Power Survey Interim Report, Power Series No. 1 from 1935. Figure 1 (a) shows the original map and Figure 1 (b) shows the geocoding of that map. Diamonds represent the location of electric generation stations and lines represent the transmission grid.

Figure 2 shows the spatial distribution of REA projects, which were heavily concentrated in the Ohio Valley, Midwest, and South. Given this, I restrict the sample to these geographic areas. The sample is restricted further to eliminate counties with over 20,000 in population as of 1930, as sparsely populated, rural counties were the target of REA funds.[7] When the sample is restricted, 1375 counties remain. For each county data from three time periods, 1930, 1934, and 1940 is used to construct the panel.

Results from OLS regressions of the observable 1930 characteristics on REA treatment status are presented in Table 1. These results reveal that areas that received REA loans were significantly different from areas that did not prior to treatment. These areas tended to have more farms, but also had lower per capita crop values. Areas receiving a loan from the REA also had lower rates of fertility in 1930, had a smaller proportion of the population aged in primary childbearing years, people aged 20-34, a more elderly population, individuals aged 45 and up, lower incomes, lower rates of marriage, a higher proportion of the population that was black, and smaller proportion of the population that was foreign born. Given the substantial differences in counties prior to treatment, OLS regressions of the average treatment effect of REA loans are likely to be biased.

Had the REA been exogenous to fertility, OLS regressions could estimate the average treatment effect of REA electrification on fertility. However, it has been noted that areas receiving funds differed substantially from those that did not, therefore, to account for pre-existing differences in counties due to time invariant characteristics, I include county fixed effects. To account for nationwide shocks to fertility I include year fixed effects. I then include baseline characteristics from 1930 interacted with year effects to allow these characteristics to

[7] Results are not sensitive to the restricted sample for various sized populations.

have a differential effect on fertility over time. I do this rather than include contemporary values because electricity is a general purpose technology and many of the variables one would like to control for are likely outcome variable. For example, the unemployment rate will be an important control affecting female labor market opportunities, however as electricity becomes available, labor market opportunities may change. The inclusion of contemporaneous values may lead to additional endogeneity problems. Thus, the baseline model to estimate is,

$$(8)\ Y_{it} = \alpha_1 + \beta_1 REA_{i,t} + \delta_t X_{1930} + \varepsilon_{it}.$$

Y_{it} is the number of live births per 1,000 women aged 14-45 in county *i* in year *t*, $REA_{i,t}$ is an indicator equal to 1 if a county received an REA loan and zero otherwise. X_{1930} is a vector of pretreatment observable characteristics including the percent of homes electrified, per capita crop value, number of farms, percent of the homes with a radio, percent urbanized, per capita retail sales, the population age distribution, percent of the population that is married, divorced, percent of the population that is black, percent foreign born, percent unemployed, and percent illiterate.

While this specification eliminates many of the potential biases, it is still possible that there are unobservable characteristics that are correlated with both the allocation of REA funds and fertility. For instance, if administrators of the REA targeted areas that they expected to experience faster/slower growth in income, then there would be a positive/negative endogeneity bias as long as there is a positive correlation between income and fertility. To address these biases, I adopt an instrumental variables (IV) strategy. Given a valid instrument the equations to estimate become

$$(9)\ Y_{it} = \alpha_1 + \beta_1 REA_{i,t} + \delta_t X_{1930} + \varepsilon_{it}$$

$$(10)\quad REA_{it} = \pi_0 + \pi_1 Z_{it} + \lambda_t X_{i,1930} + \eta_{it}.$$

As previously alluded to, the primary instrument (Z_{it}) is the distance from the nearest electric generation station as of 1935. The likelihood of receiving an REA loan is strongly correlated with the distance from a central generation station. There is strong evidence that the cost of transmission is very high for firms located at great distances from their source. In 1935, the Federal Power Commission reported that distribution losses ranged from 10-40 percent of all power sales.[8] For a fixed resistance in the electric lines, greater distance from a generation station or from a major transmission line will increase the wholesale cost of electricity. This measure is likely to be exogenous as the location of electric generation stations developed over the previous 50 years as private firms and urban municipalities sought to minimize the cost of generation and distribution for urban electrification. Furthermore, because I restrict the instrument to the pre REA grid, I do not have to worry about the changing structure of the electric generation capacity in the country in response to changes in the demand for electricity associated with the REA.[9]

I also construct other measures of access to electricity, such as the distance from the nearest transmission line and the land gradient in the county. While some authors such as Dinkelman (2011) have noted that access to the grid may affect job growth and may therefore be correlated with the error term. In this time period the grid is likely exogenous to the REA due to the development of the industry in the United States. The land gradient has also been used by several authors as a source of exogenous variation for large infrastructure projects, such as Dinkelman (2011), and Duflo and Pande (2006) who note that the geography changes the cost

[8] Federal Power Commission. National Power Survey: Cost of Distribution of Electricity. Power Series No. 5. P 56-145

[9] The REA did provide some loans for the construction of generation plants when wholesale power companies were unwilling to negotiate favorable electric rates. Between 1935 and 1939, 24 of 539 REA loans were for the construction of generation facilities.

and timing of installing infrastructure. By constructing additional instruments, I am able to use standard over identification tests of whether or not the collection of instruments are uncorrelated with the error term in the second stage regression.

5. Results

Baseline Results

Table 2 shows the baseline OLS specification using the county level fertility rate as the outcome of interest. The results show that in the absence of county fixed effects and year fixed effects, the REA is negatively correlated with fertility. When county fixed effects are included, the correlation remains negative, but is not as strong. When year effects are included, the relationship becomes positive and significant. However, when the full set of pretreatment control variables are included, the relationship between REA electrification and fertility remains positive, but is not significantly different from zero. These results are consistent with what has been found in the literature by Bailey and Collins (2009) as well as several studies in population and sociology (Harbison and Robinson 1985, Cornwall and Robinson 1988). However, neither the OLS results nor these other studies control for the endogenous expansion of electricity.

How Distance Impacts REA Electrification

In every specification, the collection of instruments predict that places further from generation stations, further from the grid, and counties that have more mountainous terrain are less likely to receive a loan from the REA. Table 3 panel (a) Columns (1) – (7) shows the first stage results when I exclude the full set of pretreatment controls. Columns (1)-(3) show the results using only one instrument at a time, Columns (4)-(6) provide results using 2 instruments at a time, and Column (7) shows the results when using all three of the instruments. I then test for the validity of the instruments using standard over identification tests. Standard errors are presented in parenthesis and are clustered at the county level to allow for arbitrary serial correlation within a county.

In Column (1) I show the primary result using the distance from the nearest central generation station as our instrument. As expected, counties that were located further away from a central generation station were less likely to receive service. The results suggest that a 100km increase in the distance from a generation station leads to a 23 percent decrease in the probability of receiving an REA loan contract. In Column (2) the results are similar for the distance from the nearest transmission line. Again for a 100km increase in distance from the grid, a county is 23 percent less likely to receive an REA loan. Column (3) shows that in places that had steeper land gradients, the likelihood of receiving an REA loan declined. Moving from the 25^{h} percentile to the 75th percentile in elevation range equates to a 4.4 percent decline in the probability of receiving an REA loan.

In each case, the instruments are strongly correlated with receiving an REA loan. The F-statistic on the first stage ranges from a low of 68 to a high of 170. The estimates are unlikely to suffer from weak instrument bias. In columns (4) – (7) I estimate the first model using all combinations of the three instruments and then p-values of the Sargan test. These tests results show that the instruments are uncorrelated with the error term. The only potential cause for concern arises when using the distance from the generation station and the distance from the grid measures, however, upon the inclusion of pretreatment controls, this concern is alleviated, which suggests conditional independence of the instrument.

In Table 3 panel (b), the first stage results with the inclusion of the full set of pretreatment controls are displayed. Once again, the results show that areas further from electric generation stations, further from the electric grid, and areas with rougher terrain were less likely to receive an REA loan. With the inclusion of all the covariates, the estimated effects are smaller in magnitude. For a 100km increase in the distance from central service electricity, the probability of obtaining an REA loan fell by 12.2 percent (Column (1)). A 100 km increase in distance from the electric grid led to a 17.5 percent decrease in the likelihood of service (Column (2)). Counties with rougher terrain were also less likely to be electrified, a move from the 25^{th} to 75 percentile makes a county 2.5 percent less likely to receive and REA loan. Once again, each specification of the model in columns (1)-(7) shows a strong correlation with the REA, and given the large F-Statistics, are unlikely to suffer from weak instrument bias. The over identification tests using the possible combinations of instruments and cannot reject the exogeneity of the instruments at traditional levels of statistical significance.

The Impact of the REA on Fertility

After instrumenting for the selection of REA loan recipients by using the variation in the cost of transmission, the results show that the REA had large effects on fertility. While fertility was in secular decline, declining roughly 12.5 percent throughout the 1930's, areas that received REA loan contracts experienced fertility increases of between 14.5 and 25 percent over their 1930 level.

Table 4 panel (a) displays the results without the inclusion of pretreatment control variables. Each entry is the effect of receiving an REA loan on fertility from a separate regression. Columns (1)-(3) show results when a single instrument is implemented, Columns (4)-

(6) show the results when 2 instruments are included in the first stage, and Column (7) shows the results when all three instruments are included in the first stage. Standard errors are presented in parenthesis below the coefficients and are clustered at the county level. Moving across the table, it is clear that the REA had a large impact on fertility. In the absence of controls, counties that received the REA loans had an increase in fertility ranging from 18 – 25 percent over the 1930 average for counties in the sample. When the all of the covariates are included in Table 4 panel (b), the results tell a similar story, fertility rose by 15.4-24.3 percent.[10]

The Primary Channel of Causality – Income Effect or Farm Labor Demand?

The identification strategy outlined above examines the impact of increased agricultural productivity through REA electrification on fertility. However the underlying theoretical outlined does not allow separate identification of the multiple channels of causality. To address this concern, I use data from agricultural censuses which reports the number of family members working on the farm as well as the number of hired workers per farm. From these measures I am able to construct an average amount of labor used in agriculture per county. The census also reports the value of implements and machinery at the county level. This measure will provide a crude measure for the value of capital. Using these variables as outcomes, it is possible to observe whether or not there was a change in the mix of inputs used to produce agricultural outputs.

Results from regressions focusing on agricultural production measures are presented in Table 5. The results show that farmers sought less work off the farm; however, this coefficient is not statistically significant. There was not an observed increase in the number of family

[10] Note, Column (3) of Table 4 panel (b) shows that there is a positive relationship between the REA and fertility, but the correlation is not statistically significant.

members working on the farm and there was not an increase in the total amount of labor used in agriculture. What this may suggest is that the patriarch of the family provided any additional labor needed without increasing the farm labor burden on additional family members that were not previously working on the farm. Additionally, the value of farm implements and machinery did not change.

Because the structure of labor and capital is not changing following electrification, it may be possible to rule out the labor demand channel of causality as a reason for the rise in fertility associated with electrification. However, there may be additional factors changing fertility.

Other Channels of Causality

While farm labor demand does not appear to be a driving factor in the observed rise in fertility, there are other possible channels which may lead to increases in fertility, such as changes in the labor market opportunities for women, changes in the cost (risk) of pregnancy, or changes in the composition of the population. To address other possible channels of causality, I specify a set of regressions examining female unemployment, retail wages, infant mortality, and migration. For each outcome below I implement the same empirical strategy as above.

The primary concern with electrification is that it changes the labor market opportunities for women, which leads them to substitute towards work and away from the home. While female labor participation data is not available until the 1940 Census, unemployment data is available for women in 1930 and 1937. If REA electrification rapidly changes labor market opportunities for women, it may be reasonable to assume that the female unemployment rate would be lower in areas that received REA loans. While this is not a direct test of the impact of the REA on female labor participation, it should provide some evidence of the effects of electrification on the female labor market. In Table 6, Column 1, I show the results using the change in the female unemployment rate between 1930 and 1937 as the outcome of interest. These results suggest that areas electrified by the REA had slightly higher female unemployment rates; however this higher rate of unemployment is not statistically significant. Given that there is little difference in unemployment, it does not appear that the REA rapidly changed labor opportunities for women outside of the farm.

While changing female employment is not a driver of the fertility change, increases in manufacturing productivity, or an expansion of the manufacturing sector may make it difficult to pin down if agricultural productivity is the driving channel of causality. Kitchens and Fishback (2012) document that the REA did not increase the productivity of manufacturing in terms of value added or lead to an increase in the number or manufacturing establishments. They do find evidence that the average annual earnings of manufacturing employees rose and attribute this rise to competition for labor between rural and urban locations. Given that manufacturing was not the primary industry in the regions electrified by the REA it is unlikely that an increase in manufacturing wages will lead to large increases in fertility. However, if other sectors also experienced increased wages, there may be some concern over the causality of the fertility estimate, as a general increase in wages may be the driving the observed rise in fertility. Therefore, it is useful to examine the wages paid in other sectors of the economy such as retail establishments. Column 3 of Table 5 shows the results of a regression where I compare the change in retail establishment wages between 1929 and 1939. The results show that the retail wages paid in counties with REA loans are not statistically significant. This suggests that that the REA was not changing wages throughout the electrified area, with the exception of manufacturing.

Migration may also be a cause for concern. Kitchens and Fishback (2012) also show that there were increases in rural farm populations associated with the REA. This change in population may have compositional effects which impact fertility decisions. To further examine the changing population, I use the net migration variable constructed by Fishback, Horrace, and Kantor (2006). Using their net migration variable, I find that there is a statistically significant increase in migration. For counties that gained REA electricity, migration increased by 2.8-3.6 percent, depending on which migration variable is used. This increase, while statistically positive seems too small in magnitude to cause a change in the composition of the county leading to a large increase in fertility. However, it is possible that migration played a small role in the increase in fertility.

The 1920's and 1930's were a period of rapidly changing women's and infant health. It has been shown these improvements can lead to increases in fertility (Albanesi and Olivetti 2011). If REA electrification led to rapid improvements in infant health, this may be a channel through which fertility would increase. Column 5 of Table 6 shows the results using the county level infant mortality rate as the outcome of interest. These results show that infant mortality was not differentially affected by REA electrification, and thus is unlikely to influence fertility decisions.

Threats to Validity

While the evidence thus far suggests that increases in agricultural productivity are increasing fertility, there are additional threats to the identification of the causal effect. The primary threats to the validity of the identification strategy are other government programs established during the New Deal targeting either electrification or agriculture. Two major programs come to mind in these areas, the Agricultural Adjustment Administration (AAA), and the TVA. The AAA gave money to farmers to idle land and it has been shown by Depew, Fishback, and Rhode (2012) that the funds were not randomly distributed and had differential effects on certain populations, particularly by impacting blacks and sharecroppers. If the AAA was negatively correlated with REA electrification, due to more upheaval in the communities, then the primary IV estimates presented in the previous section would understate the true impact of the REA. Electrification by the TVA will be examined in more detail below, however if it is correlated with the REA there is potential for the REA coefficient to be biased. The TVA was a comprehensive development agency in the Southeast United States and had its own electrification programs. Kitchens (2012) notes that the TVA and REA often worked in conjunction on projects, which may lead to biased point estimates.

To address the impact of the AAA on the results, I re-estimate the model including the total AAA payments made in counties during the New Deal. I find that the point estimate for the impact of the REA on fertility remains unchanged. Because the AAA is potentially endogenous, I re-estimate the IV model adopting a similar IV strategy used in Depew, Fishback, and Rhode (2012). In their work they use the number of acres in cotton production prior to the AAA because AAA payments to farmers were based on historic cotton yields. Analogously, I use the number of acres in all crops in 1929 as a proxy for their measure. The results show that the number of acres in 1929 is highly correlated with AAA payments. The second stage estimates remain relatively unchanged. The point estimate falls from 15.7 to 13.7, but is not statistically different from the baseline estimates. These results are summarized in Table 7.

To ensure that the baseline estimate is not biased by the presence of TVA electrification programs, I re-estimate the model by dropping counties in Alabama, Mississippi, and Tennessee, the region where the TVA was operating at the time. When this is done, the point estimate of the REA's impact on fertility remains unchanged. These results are also presented in Table 7, Column (3).

6. Electricity Without Increased Productivity

Most studies have found a negative or no relationship between fertility and electrification. This begs the question: How is the REA different than other electrification initiatives? In most studies, authors seek to correlate the expansion of electric light service with fertility (Bailey and Collins (2009), Lewis (2012)). However, if there are large nonlinearities going from no electricity to electricity, these studies likely miss this effect which is most relevant for policy analysis. Furthermore, the areas of urban population, which would be most heavily weighted in regressions reporting average treatment effect by these authors, were almost entirely electrified prior to their sample, and would only experience very minor increases in electrification. The REA was in most cases the first exposure of rural farms to electricity.

As an additional check to determine if the productivity shock induced by the REA is the primary channel of causality, I examine the electrification experience of the TVA, which was an expansion of the electric grid during the same time period in a similar region, but did not create an agricultural productivity shock. Kitchens (2012) examines the expansion of the TVA service area on a variety of outcomes using an empirical strategy that relies on changes in the cost of electric service when new TVA dams are constructed. The key identifying assumption in that work is that TVA dams are placed according to a 1930 U.S Army Corps of Engineers Report to prevent flooding on the Mississippi River and are not constructed to meet expanding electricity demand throughout the 1940's and 1950's. Those results show that the TVA was not a productivity shock and that electrification grew at a similar pace to areas not electrified by the TVA. The primary difference between the REA and the TVA is that the TVA expanded electric service on pre-existing infrastructure rather than bringing electricity to areas that had never experienced it.

Following the methodology outlined in Kitchens (2012), I estimate the outcome variable of interest Y_{it} (annual county level fertility) on an indicator equal to one if county *i* has an electric contract with the TVA in year *t*, controlling for a variety of 1930 characteristics, county fixed effects δ_i, year fixed effects $\gamma_t$and state by year fixed effects $\gamma_t\lambda_s$. To account for the potential endogeneity of TVA electricity contracts, I instrument for them by using the inverse of the minimum distance to the nearest TVA dam (Z_{it}). The set of equations I estimate are,

$$(11) \quad Y_{it} = \alpha_0 + \alpha_1 TVA_{it} + \beta_t X_{i,1930} + \delta_i + \gamma_t + \gamma_t\lambda_s + \varepsilon_{it}$$

$$(12) \quad TVA_{it} = \pi_0 + \pi_1 Z_{it} + \delta_t X_{i,1930} + \delta_i + \gamma_t + \gamma_t\lambda_s + \eta_{it}.$$

As new TVA dams are constructed, the distance between a county and the generation source falls, making it less expensive to be electrified by the TVA. The data used in exercise are the county level annual fertility rates from 1930-1950 for states located in the Southeast United States. Data pertaining to TVA contracts and the instrument are from Kitchens (2012).

In this empirical exercise if there is no increase in fertility associated with the TVA, it would suggest that the causal link between electrification and fertility in the case of the REA comes through increases in agricultural productivity, which is associated with obtaining electricity for the first time rather than through gradual increases in electrification. One question that arises when examining the TVA region is whether or not the counties electrified by the TVA substantially differ from areas targeted by the REA. Figure 4 shows the final electric service area of the TVA imposed over REA loan projects. County borders are drawn to signify the TVA service area and REA projects are shaded. There are several counties in the TVA service area which were first electrified by the REA, suggesting that this region is the exact sort of area targeted by the REA, which should make this an ideal place to contrast the electrification experience of the TVA and REA.

The results from this set of regressions show the often reported lack of an empirical relationship between electrification and fertility shown by Harbison and Robinson (1985), Cornwall and Robinson (1988), Bailey and Collins (2009), and Lewis (2012) among others. The full results are presented in Table 8 with standard errors clustered on the county in parenthesis. The results are presented by decade and for the entire time period both with and without the inclusion of State-Year fixed effects. My interpretation of this result is that fertility increases associated with electrification only occur if electrification increases productivity without changing opportunities for women. The permanent increase in income only occurs when electricity first arrives, so in order to truly understand the impacts of electrification, scholars must look for examples where communities receive service for the first time. In areas that already have electricity either in the home or in businesses, small increases in the electrification rate are unlikely to change labor market opportunities or production technologies because firms and households have already adopted the new technological innovation when it arrived.

7. Conclusions

Previous research has noted that when there are income shocks for males, fertility usually increases. However, the empirical literature focusing on the relationship between electrification and fertility has shown that there is traditionally a negative relationship. What I do in this paper is look at a unique event in American history, the establishment of the REA, to determine the impact of rural electrification on fertility when electricity arrives for the first time.

Using plausibly exogenous variation in the cost of electric distribution, I am able to compare counties that had the same probability of receiving an REA project. Using this comparison, I find that counties that received an REA project had fertility rates that were 14.5-25 percent higher than counties that did not receive a project. To determine if the rise in fertility is in response to an income shock or changing labor demand on the farm, I examine farm variables and determine that labor demand did not significantly change on the farm, indicating that the primary channel of causality is the income effect.

I further examine other possible channels of causality, such as changes in female labor market opportunities, migration, and changing risks of pregnancy. These regressions indicate that the income effect is the primary channel of causality.

I then highlight the importance of obtaining electricity for the first time by comparing the experience of the REA with the TVA, which expanded electricity over an area that had previously had access to electricity. These results show that the TVA did not lead to increases in fertility. In part, this exercise helps explain the results that do not align with prior research in this area. I conclude from this exercise that in order for electrification to lead to an increase in fertility, electrification must be associated with a productivity shock.

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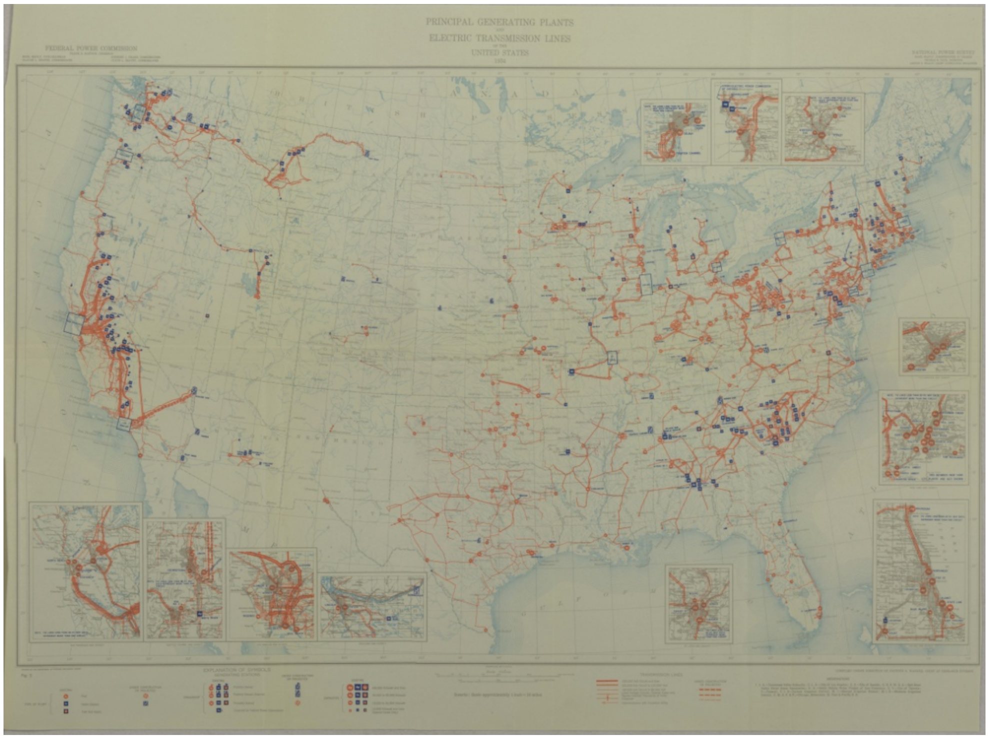
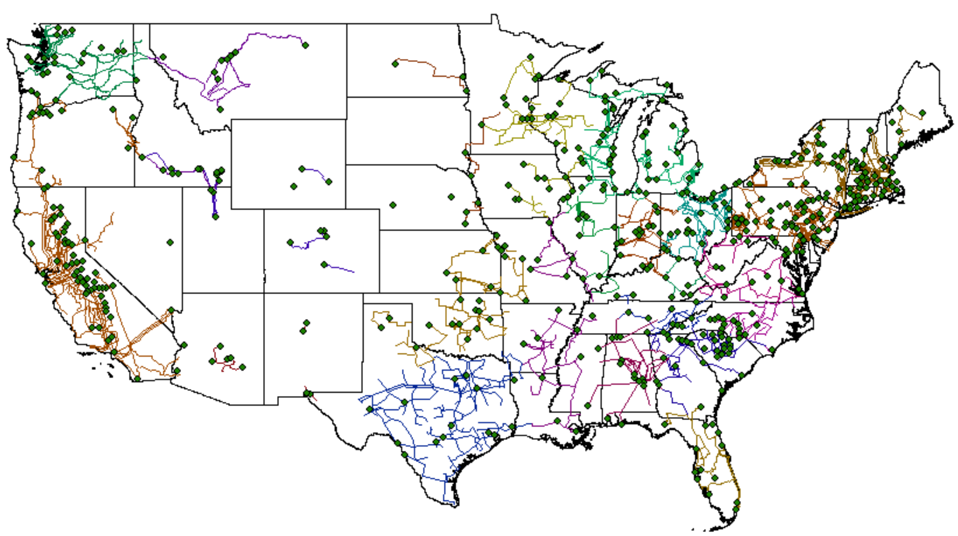
Figure 1: 1935 Electric Transmission Grid in United States



(a)



(b)

Figure 2: Service Area of Individual REA Funded Projects 1939

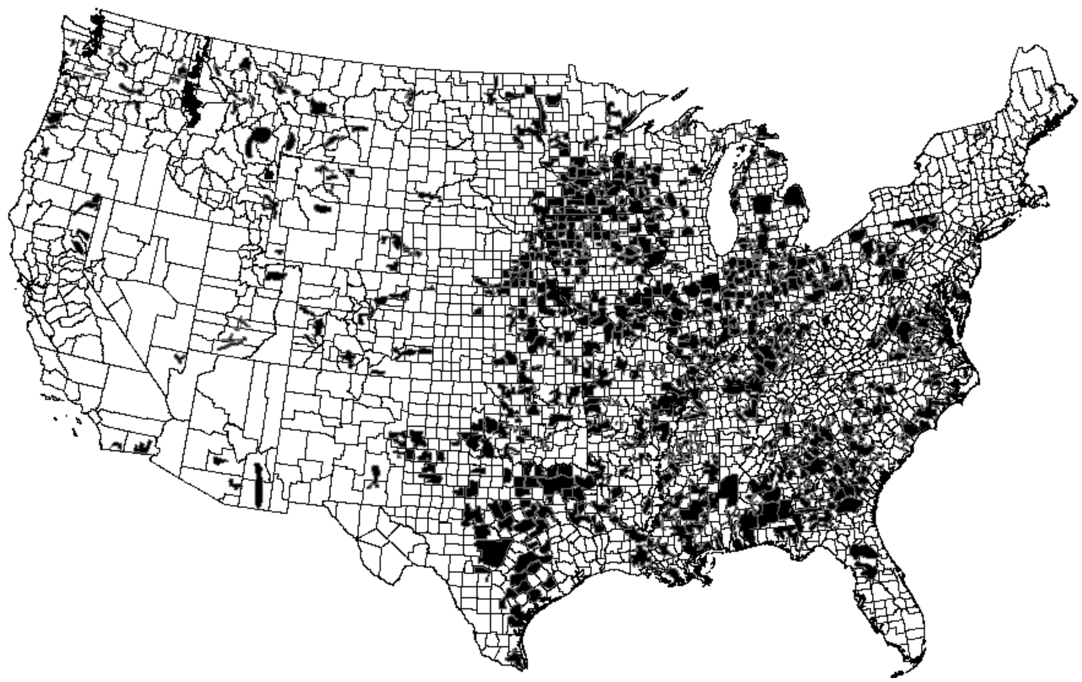
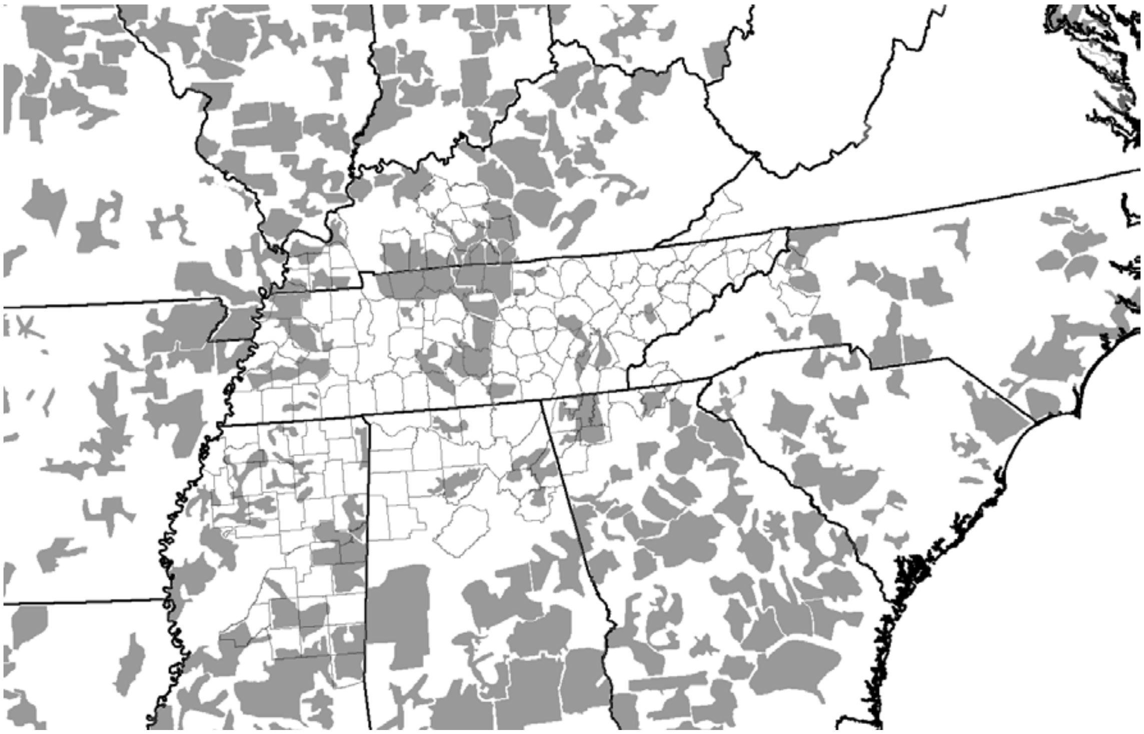


Figure 4 – TVA and REA Overlap Map



Note: The TVA service area boundary is displayed with county borders. REA projects are denoted by shaded regions.

Table 1 Difference in Means by REA Status

Summary Statistics - 1930 Characteristics		
	Coef.	Std Er.
1930 Fertility Rate	**-2.7308**	1.456
Percent Electrified 1930	-0.0133	0.011
Per Capita Crop Value	**-24.294**	7.452
Number of Farms	**489.261**	36.869
Retail Sales Per Capita 1929	**-39.354**	6.816
Percent Unemployed	**-0.001**	0
Percent Owning Radios	-0.9526	0.956
Percent Urban	0.00069	0.009
Percent Aged 10-19	0.15014	0.13
Percent Aged 20-29	**-0.9864**	0.119
Percent Aged 30-34	**-0.3126**	0.046
Percent Aged 35-44	-0.0989	0.071
Percent Aged 45-54	**0.39231**	0.074
Percent Aged 55-65	**0.75382**	0.09
Percent Aged 565-74	**0.67331**	0.076
Percent Aged 75+	**0.38037**	0.039
Percent Married	**-1.7247**	0.221
Percent Divorced	**-0.0437**	0.026
Percent Black	**5.06989**	1.01
Percent Foreign Born	**-1.0175**	0.279
Percent Illiterate	0.00184	0.002

Note: Each entry is from a separate regression of the given characteristic in 1930 on REA treatment status.

Table 2 – OLS Results: Fertility on REA Status

OLS Results: Dependent Variable = County Level Fertility

	1		2		3		4
REA	-8.454	***	-9.336	***	2.108	**	0.253
	(0.982)		(0.573)		(0.929)		(0.995)
County FE	No		Yes		Yes		Yes
Year FE	No		No		Yes		Yes
Controls	No		No		No		Yes
R^2	0.017		0.079		0.167		0.271
N	3884		3884		3884		3765

* p<.1, ** p<.05, *** p<.01

Notes: Each coefficient is from a separate regression. Each Regression Includes the 1929 or 1930 value of the percent of homes electrified, per capita crop value, number of farms, percent of the homes with a radio, percent urbanized, per capita retail sales, the population age distribution, percent of the population that is married, divorced, percent of the population that is black, percent foreign born, percent unemployed, and percent illiterate. Each of these variables is interacted with a year indicator variable to allow them to have a differential effect in each year. Standard errors are clustered on the county level.

Table 3 – 1st Stage Regression Results

	1st Stage Results						
	1	2	3	4	5	6	7
Distance From Generation Station	-0.0023 ***			-0.0011 ***	-0.0023 ***		-0.0011 ***
	(0.00018)			(0.00023)	(0.00018)		(0.00023)
Distance From Transmission Grid		-0.0024 ***		-0.0017 ***		-0.0023 ***	-0.0017 ***
		(0.00016)		(0.00021)		(0.00016)	(0.00021)
Elevation Range			-0.0001 ***		-0.0001 ***	-0.0001 ***	-0.0001 ***
			(0.00001)		(0.00001)	(0.00001)	(0.00001)
F-Stat	170.17	210.16	68.89	120.51	120.85	141.07	103.45
Sargan Statistic P Value				0.0923	0.3451	0.8543	0.2235

*p<.1, **p<.05, *** p<.01

(a)

	1st Stage Results						
	1	2	3	4	5	6	7
Distance From Generation Station	-0.001 ***			0	-0.001 ***		0 *
	(0.00020)			(0.00024)	(0.00020)		(0.00024)
Distance From Transmission Grid		-0.002 ***		-0.002 ***		-0.002 ***	-0.001 ***
		(0.00019)		(0.00020)		(0.00019)	(0.00023)
Elevation Range			-0.0001 ***		-0.0001 ***	-0.0001 ***	-0.0001 ***
			(0.00001)		(0.00001)	(0.00001)	(0.00001)
F-Stat	35.37	80.33	20.38	41.26	28.35	48.11	33.05
Sargan Statistic P Value				0.3493	0.1346	0.2389	0.3141

*p<.1, **p<.05, *** p<.01

(b)

Note: Each Regression Includes the 1929 or 1930 value of the percent of homes electrified, per capita crop value, number of farms, percent of the homes with a radio, percent urbanized, per capita retail sales, the population age distribution, percent of the population that is married, divorced, percent of the population that is black, percent foreign born, percent unemployed, and percent illiterate. Each of these variables is interacted with a year indicator variable to allow them to have a differential effect in each year. Standard errors are clustered on the county level.

Table #4 Second Stage IV Regression Results without the Inclusion of Pre-Treatment Controls

2nd Stage Results - REA on Fertility

	1		2		3		4		5		6		7	
REA	17.265	***	23.224	***	23.977	***	20.770	***	19.215	***	22.997	***	21.440	***
	(3.871)		(3.667)		(6.270)		(3.376)		(3.334)		(3.198)		(3.027)	
County FE	Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Year FE	Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Pre-Treatment Controls	No		No		No		No		No		No		No	

*p<.1, **p<.05, *** p<.01

(a)

2nd Stage Results - REA on Fertility

	1		2		3		4		5		6		7	
REA	24.394	***	17.531	***	3.482		18.396	***	16.702	**	14.896	***	15.744	***
	(8.947)		(5.683)		(10.499)		(5.642)		(6.694)		(5.122)		(5.074)	
County FE	Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Year FE	Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Pre-Treatment Controls	Yes		Yes		Yes		Yes		Yes		Yes		Yes	

*p<.1, **p<.05, *** p<.01

(b)

Note: Each Regression Includes the 1929 or 1930 value of the percent of homes electrified, per capita crop value, number of farms, percent of the homes with a radio, percent urbanized, per capita retail sales, the population age distribution, percent of the population that is married, divorced, percent of the population that is black, percent foreign born, percent unemployed, and percent illiterate. Each of these variables is interacted with a year indicator variable to allow them to have a differential effect in each year. Standard errors are clustered on the county level.

Table 5 – Farm Labor Demand Variables

	Female Unemployment	Retail Wages	Net Migration	Net Migration 2	Infant Mortality
REA	0.708	-82.771	36.03	28.63	11.25
	(0.547)	(136.937)	(11.075)	(9.088)	(13.891)
First Difference	Yes	Yes	Yes	Yes	No
Pre-Treatment Cont	Yes	Yes	Yes	Yes	Yes

*p<.1, **p<.05, *** p<.01

Note: Columns 1-5 use first differences as these of the outcome variable as 2 years of the outcome are typically available. In these cases standard errors are White robust errors. Each regression includes the 1929 or 1930 value of the percent of homes electrified, per capita crop value, number of farms, percent of the homes with a radio, percent urbanized, per capita retail sales, the population age distribution, percent of the population that is married, divorced, percent of the population that is black, percent foreign born, percent unemployed, and percent illiterate as covariates.

Table 6 – Additional Channels of Causality

	Female Unemployment	Retail Wages	Net Migration	Net Migration 2	Infant Mortality
REA	0.708	-82.771	36.03	28.63	11.25
	(0.547)	(136.937)	(11.075)	(9.088)	(13.891)
First Difference	Yes	Yes	Yes	Yes	No
County FE	No	No	No	No	Yes
Year FE	No	No	No	No	Yes
Pre-Treatment Controls	Yes	Yes	Yes	Yes	Yes

*p<.1, **p<.05, *** p<.01

Note: Columns 1-4 use first differences as these of the outcome variable as 2 years of the outcome are typically available. In these cases standard errors are White robust errors. Column 4 is a panel regression using county level infant mortality as the outcome of interest. Standard errors in Column 5 are clustered at the county level. Each regression includes the 1929 or 1930 value of the percent of homes electrified, per capita crop value, number of farms, percent of the homes with a radio, percent urbanized, per capita retail sales, the population age distribution, percent of the population that is married, divorced, percent of the population that is black, percent foreign born, percent unemployed, and percent illiterate as covariates.

Table #7 – Robustness Checks of AAA and TVA

	AAA				TVA	
	IV REA		IV REA and AAA			
	1		2		3	
REA	15.944	***	13.758	***	15.957	***
	(5.083)		(4.816)		(5.061)	
County FE	Yes		Yes		Yes	
Year FE	Yes		Yes		Yes	
Pre-Treatment Controls	Yes		Yes		Yes	

*p<.1, **p<.05, *** p<.01

Note: Column 1 instruments for the presence of an REA loan and includes AAA spending in the county as a regressor on the right hand side. Column 2 allows AAA to be endogenous and follows the IV strategy outlined in Depew, Fishback, and Rhode (2012). Each regression includes Column 3 reports the results when counties in AL, MS, and TN are dropped to account for the primary TVA service area. Each regression includes the 1929 or 1930 value of the percent of homes electrified, per capita crop value, number of farms, percent of the homes with a radio, percent urbanized, per capita retail sales, the population age distribution, percent of the population that is married, divorced, percent of the population that is black, percent foreign born, percent unemployed, and percent illiterate as covariates. Each of these variables is interacted with a year indicator variable to allow them to have a differential effect in each year. Standard errors are clustered on the county level.

Table #8 – Fertility on TVA Electric Contract Status

	TVA Electrification on Fertility					
	1930-1940	1930-1940	1940-1950	1940-1950	1930-1950	1930-1950
TVA	-4.193	3.202	26.077	7.98	11.831	-1.967
	9.638	52.805	26.859	27.393	11.555	25.23
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State X Year FE	No	Yes	No	Yes	No	Yes
Pre-Treatment Controls	Yes	Yes	Yes	Yes	Yes	Yes
F-Statistic 1st Stage Instrument	190.63	8.8	346.75	297.01	1403.57	349.46

*p<.1, **p<.05, *** p<.01