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THE SPATIAL IMPACT OF THE RURAL ELECTRIFICATION ADMINISTRATION 1935-1940

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Working Paper 19743
http://www.nber.org/papers/w19743

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
December 2013

The authors would like to thank seminar and conference participants at University of Arizona, University of Mississippi, Florida State University, 7th World Congress of Cliometrics, and Southern Economic Association Annual meetings. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

At least one co-author has disclosed a financial relationship of potential relevance for this research. Further information is available online at http://www.nber.org/papers/w19743.ack

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December 2013
JEL No. N12,O13,O38

ABSTRACT

To isolate the impact of access to electricity on local economies, we examine the impact of the Rural Electrification Administration low-interest loans in the 1930s. The REA provided loans to cooperatives to lay distribution lines to farms and aid in wiring homes. Consequently, the number of rural farm homes electrified doubled in the United States within 5 years. We develop a panel data set for the 1930s and use changes within counties over time to identify the effect of the REA loans on a wide range of socio-economic measures. The REA loans contributed significantly to increases in crop output and crop productivity and helped stave off declines in overall farm output, productivity, and land values, but had much smaller effects on nonagricultural parts of the economy. The ex-ante subsidy from the low interest loans was large, but after the program was completed, nearly all of the loans were fully repaid, and the ultimate cost to the taxpayer was relatively low.

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1. Introduction

Access to electricity has long been considered a major contributor to the economic welfare of populations. Households with electricity have better access to information and the use of a broader range of consumer goods, while farms and firms find it enhances productivity in a variety of ways. These anticipated benefits have led the World Bank to provide extensive loans and grants to aid less developed countries in bringing electricity to the 15 percent of the world population that lives without it.[1] A number of recent studies have examined the effects on economic activity of new dams and other large infrastructure projects, which include increased access to electricity as one of the significant benefits (Duflo and Pande (2007), Kitchens (2013), Kline and Moretti (2013), Lipscomb, Mobarak, and Bahram (2012), and Severini (2012). Yet, these studies cannot fully isolate the benefits of electrification because the projects often have multiple purposes and involve large construction efforts. Most dams aid economic activity in an area not only through electrification, but also through flood control, irrigation, and recreation opportunities. The construction process often leads to the building of roads and railways to small cities that develop around the dam site.

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[1] In 2012 1.3 billion people lived without electricity, and one-third of the African population lives without access to electricity. Annually, the World Bank provides over $8 billion in energy related loans to projects that including building coal-fired power plants in South Africa to expanding distribution networks in Kenya, to building large-scale dams in Ethiopia. (World Bank 2012, 2013; Reuters 2010; Reuters 2012; Hidassee 2013).

Even though the construction city may not last long, the extra business provided for nearby cities has the potential to lead to persistent effects over time.

To refine the estimates of the impact of access to electricity on economic activity, we perform a study of the Rural Electrification Administration (REA), which was exclusively devoted to the distribution of electricity to rural areas for the first time. The REA was established in 1935 to provide loans to lay power lines from the existing electricity grid to rural areas where electricity was not available. This was a period when incomes in many of these rural areas were at modern developing world levels, as was the road infrastructure. In its first five years of operation, the REA provided over $227 million in loans ($3.6 billion in 2010 dollars) to survey areas, lay distribution lines, and wire homes.[2] The REA's initial push more than doubled the number of electrified farms in the U.S. The number of farms electrified in that period was more than the number electrified in the 53 years between the start of central distribution of electricity and the introduction of the REA. In just 5 years, cooperative utilities had more mileage of distribution line than the 5 largest private utilities in the country (Slattery 1940). Today cooperative utilities serve over 42 million people in 47 states, maintain 42 percent of the nation's distribution lines, and deliver 11 percent of all electricity (NRECA 2013).

[2]The REA built a handful of diesel electric generation plants, which accounted for about 3.7 percent of the total loans.

To measure the impact of the REA loans, we develop a new panel data set for the 1930s with information on the REA loans, other New Deal programs, and a wide range of socioeconomic measures: population growth and migration, agricultural output and productivity for multiple goods, land values, the use of labor and machinery on farms, the extent of manufacturing activity, retail consumption, earnings outside agriculture, and birth rates and infant mortality rates.[3] The impact of the REA is identified using variation within counties over time and controls for the primary form of selection used by the REA in choosing projects, distance from the existing electric grid in 1935. REA officials distributed the loans to projects that were closer to the existing electric grid because they sought to insure that the loans would be repaid, and the electricity delivery costs to more distant areas were high enough that the longer distance projects would not succeed. Placebo tests suggest the absence of selection bias in our analysis the distribution of the loans by showing no relationship in a similar analysis of changes in economic outcomes in the 1920s as a function of the distribution of REA loans between 1935 and 1940.

The REA was introduced into rural economies that in many cases had not yet recovered to their 1929 levels. The loans contributed substantially to a rise in overall crop output, crop output per farm, and crop output per acre. In addition,

[3] Taryn Dinkelman (2011) performed a similar study of electricity distribution in modern South Africa but she focused on female labor supply.

the REA loans helped stave off longer run declines in the number of farms and overall output on farms. These positive benefits also helped stave off declines in the value of land and buildings on farms. The effects on nonagricultural parts of the economy were generally small, which is not a surprise given the tight focus of the REA on electrifying farms and the disruptions in labor markets during the Great Depression and the New Deal.

Finally, the REA was an inexpensive program to taxpayers. When there is a choice between extending distribution lines or building new plants, extension of distribution lines is much cheaper than building new dams and likely reaches more people faster than other electric infrastructure investments. The subsidy to farmers and investors who formed the cooperatives to lay the distribution lines came in the form of interest rates on the REA loans that were 2 to 3 percentage points lower than the rates they would have expected to pay in private markets that incorporated the anticipated risk of the loans into the interest rates. The ex-ante size of the subsidy was in the range of 18 to 26 percent of the value of the loans. Ex post, however, almost all loan recipients were either on schedule or ahead of schedule on their repayments of principal on the loans (USDA 1943). As of 1960, less than 1 percent of REA loans were behind more than 30 days on payments (NRECA 1960). The REA had much greater success at obtaining repayments than some other major projects, like the Home Owners' Loan Corporation (HOLC), which foreclosed on 20 percent of its loans (Fishback, Rose, and Snowden 2013), and the Bureau of Reclamation, which did not charge interest on the loans to irrigation districts to construct dams, and eventually forgave the principal payments on the loans on many projects as well.

2. The Rural Electrification Administration

In 1930, almost every major city and town was electrified.[4] Nationwide, approximately 28 percent of households in towns and cities had access to electricity. Despite the large growth of the electric grid from1880 to 1930 and rapidly declining prices, only 3.2 percent of farms were electrified in 1925, 10 percent by 1930. By 1950, the landscape had changed dramatically, as over 90 percent of farms had become electrified.

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. Between 1935 and 1939, the REA handed out the equivalent of 0.3 percent of GDP in government subsidized loans to newly formed cooperative utilities and existing private utilities to provide access to electricity in rural areas. By 1940, over 250,000 miles of line had been constructed with REA loans. The lines connected over 956,000 farms and thus more than doubled the number of farms receiving service as of 1935, despite the

[4] The Federal Power Commission reported electric rates for over 19,000 towns and cities in 1935 with populations greater than 250 residents.

continued problems with recovery from the Depression in the agricultural sector (Slattery 1940).

The REA Loan Process

The REA provided twenty-five year loans at interest rates pegged to the long term U.S Treasury bond rate for the construction of distribution lines to electrify farms. REA rates fluctuated from 2.69 to 3 percent at a time when most loans of this type charged 6 percent interest (Slattery 1940). In other cases, the REA offered 5-year loans to help with the wiring of homes (Slattery 1940). In a handful of cases, the REA extended loans to construct generating plants. Upon loan approval, the REA helped line up engineers and experts to see that the proposed project was completed satisfactorily (REA Annual Report 1937). The REA also provided training for the managers of newly formed cooperatives to help ensure that the new organizations were run successfully so that the loans would be repaid according to schedule from power revenues.

To obtain a loan, an organization, typically cooperatively owned, proposed a plan that included engineering drawings and justification of the loan allotment. As a part of the plan submitted to the REA, the organization had to be incorporated under its state's laws, have secured rights of way, and begun negotiations to secure a wholesale power source. The applicant was required to have legal representation, a project engineer, and an accurate map of the project subject to verification by the REA (REA Annual Report 1937).

The typical REA project required $230,000 (3.6 million in 2010 dollars) in loans to construct 250 miles of rural distribution lines to connect about 800 customers. Roughly 75 percent of these customers were farms. The rest were schools, churches, general stores, and small shops.

One major hurdle to receiving a loan from the REA was securing wholesale power at a low rate as power cost represented approximately 75 percent of the total payments made by loan recipients (REA 1938b). There were far more applicants for loans than the funds available could aid, and the REA sought to ensure that loans were repaid. Given that the loan would be paid back with power revenues, the REA treated the securing of wholesale electricity at a low cost as a very important component of whether or not an applicant would be approved. As the REA noted,

> In terms of the feasibility of projects, the power cost is the largest item of cost in connection with their operation….We have taken the position that if a proposed wholesale rate for any project, taking into account variable conditions, is not such as to make an otherwise good project economically feasible and self-sustaining, REA cannot make a loan (REA 1938b).

> “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 1937, REA1938b, Slattery 1940) [5]

Anecdotally, the proposed wholesale rate and retail rates were binding constraints. As early as 1935, Morris Cooke, then director of the REA, rejected loan applications if the rate was too high (Richardson 1961). The relationship between electric rates and the allocation of funds will inform our empirical strategy below.

The Relationship with Lenders

After the funds were allocated by Congress, it proved difficult at first to deliver funds into the hands of private utilities, municipalities, or cooperative utilities to begin construction. While surveys undertaken by the Federal Emergency Relief Administration (FERA) indicated that there was large rural demand for electricity, both farmers and states were unfamiliar and leery of the cooperative utility’s organizational form (Richardson 1961).

The REA changed the organizational structure of electric utilities and the way customers connected to the electric grid. Given the REA’s stringent rate

[5] Slattery 1940 also notes “Too high rate or onerous conditions may wreck a project, the contract must be approved by our engineers. It is not a matter for novices. Tense battles are frequently fought over this issue. If unable to secure a wholesale rate of about 1 cent per kwh, the REA loans money to build its own generating station, usually powered by diesel engine ... if it is decided that the project is feasible and will pay out, construction estimates are prepared, a sum is fixed to cover all costs and a recommendation for an allotment is made to the Administrator for his approval and signature.” (p58-59 Rural America Lights Up)

structure requirements, many private utilities did not apply for loans, believing that REA rate requirements would yield unprofitable projects (Richardson 1961). As a result, 90 percent of REA funds were loaned to cooperative utilities, which were nonprofit member-owned corporations (REA 1939b). In many states, it was unclear how to incorporate cooperative utilities, how they should make payments in lieu of taxes given their non-profit status, and whether they should be regulated by state public service commissions. To solve this issue, the REA wrote a model bill to recognize and incorporate the cooperative utilities (Slattery 1940). By 1940, 23 states passed the model bill that allowed the cooperatives to be exempt from regulatory authority on the basis that they were self-regulating; in other states cooperatives were organized under existing agricultural cooperative legislation, adapted to meet the needs of electric cooperatives (REA 1960).

While the REA aided in addressing legal issues at the state level, it also aided in the process at the local level. Many farmers were suspicious of joining cooperative organizations because many agricultural cooperatives, such as dairies, had failed in the 1920s (Richardson 1961). To increase awareness of the REA program, officers from the REA frequently attended local farm meetings in conjunction with the local agricultural extension agents to advertise and encourage the formation of a rural cooperative utility. At these meetings, the agents described the benefits of electricity on the farm, lighting, pumped water, milling, as well as the cost of obtaining electricity. REA agents outlined the step-by-step instructions to secure a loan, “Get a county map and mark on the map where the line should go to serve the farms that want electricity. Find out what wholesale rate you can get. Send in this information and the REA will tell you whether the project is feasible and what engineering and legal steps to take next… The REA has a legal division that will tell you all about the state laws which govern your organization” (REA 1936b)

Early on, meetings were often hijacked by private companies who sent representatives to ask loaded questions during the meetings designed to raise doubts about the risks to which individual farmers would be exposed in the event of default. In reality, farmers only risked a five dollar membership fee (REA 1938b). Despite, the true low cost and lack of risk, the fears instilled by the private utilities were sufficient to stall or prevent the formation of some cooperatives (Richardson 1961).

Further challenges arose at the local level during the loan process. In order to construct the distribution system, loan applicants had to secure easements, often without the power of eminent domain, which proved difficult in areas with many disjoint landowners. The REA helped overcome this problem by issuing standard procedures to acquire easements by including members of each locality on their board of directors (REA 1938, Richardson 1961). This procedural innovation made it easier to track down absentee landowners and increased the transmission of information, making it easier to construct distribution lines.

In addition to the legal innovations, REA engineers made technological innovations to reduce the cost of distribution lines. Designs created by REA engineers allowed spans between poles to be doubled, removed bulky hardware, and ultimately lowered the cost of lines from $2,000 per mile to $850 per mile (REA 1938b). Coordinated efforts and assembly line construction of distribution lines also reduced the length of time that if took to construct distribution lines by over 60 percent (REA 1938b). These innovations and suggested construction practices were developed by REA engineers (REA 1936c).

Within the cooperative organization, the REA also played significant roles. The REA closely monitored the applicants in all phases of development. The REA helped applicants secure wholesale power contracts and protected applicants by developing standard wholesale contracts to eliminate unfavorable clauses that might jeopardize the applicant's financial health (REA 1938b). To ensure the quality of project coordinators, managers, and accountants, the REA had to approve selections and routinely offered training courses to inform cooperative employees of sound business practices (REA 1938b). This was especially important for standardizing accounting purposes so that the REA could track the financial health of its loans. The REA trained cooperative accountants and managers in standard bookkeeping practices to move them away from simple

Inbox-Outbox methods (Richardson 1961). All of these measures were taken to make the new cooperatives self-sufficient and to minimize the risk of default.

By 1938, the REA listed over 200 uses for electricity on the farm (REA 1938b). Electricity meant increased productivity along multiple dimensions. Kilowatts pumped water for irrigation and watered animals, allowing for more crops to be planted and increased consistent quality. For example, the use of electricity reduced the worminess of artichokes by attracting moths to light blue light traps. Apple farmers in Virginia adopted spray irrigation, which increased their yield and the grade of the product. Electric motors could be operated more cheaply and tended to break down less often than gas motors (REA 1936b). Electric heaters in chicken coops increased hatch rates and the size of chickens. At the agricultural experiment stations, electricity increased the profitability per hen by 23 cents in Missouri and 53 cents in Alabama (REA 1938b). Lighting in pig pens reduced the number of offspring lost to accidental trampling deaths, if one piglet was saved it completely offset the cost of power for the year. Dairy farmers also benefitted, electricity meant cooled storage tanks and automated milking machines. More milk received high grades, less milk spoiled, and it could be collected with 50 percent less labor. Running water in the barn also led to increased milk production by cows, which no longer had to wait for fresh water. In Indiana, electricity reduced the length of time that plants spent in the greenhouse and increased the number of blooms on flowers.

Electricity was also beneficial in the home. The REA estimated that for the average family of five, over 300 hours and 350 miles of walking per year could be eliminated in the collection of water (REA 1938b). Electric water heaters further reduced the labor associated with heating water for cooking and baths. Electric lighting also reduced smoke and ash in the home by replacing kerosene lighting. Electricity also introduced a variety of appliances into the home such as electric ranges, washing machines, and electric irons. All of these goods improved the quality of life for rural residents.

3. **A Model of Farm Profitability**

Access to electricity potentially led to changes on a wide range of dimensions in rural areas. To provide a framework for discussing these changes, we use a model developed by Roback (1982), and used more recently by Greenstone, Hornbeck, and Moretti (2010), Moretti (2011), Hornbeck and Keskin (2012), and Severnini (2012) to examine how electrification changed the profitability of firms in a given location. We use the model to discuss the profitability of farms because of the REA's focus on providing access to electricity to farms in rural areas. In the model, there are two locations, farms in each location have a production function with a location specific productivity parameter, A. The farms use labor (L), capital (K), land (T), and energy inputs (E) to produce a single internationally traded good with the price normalized to 1.[6] The farms in each location maximize the following profit function

$$(1)\ \max_{L,K,T,E}\ f(A,L,K,T,E) - wL - rK - qT - sE.$$

The input prices are *w* for labor, *r* for capital, *q* for land, and *s* for energy. From the first order conditions, farms choose the profit-maximizing levels of each input as a function of the factor prices. For instance, $E^*(A,w,r,q,s)$, is the optimal use of energy in a given location. Similarly, the farm can solve for its optimal use of labor, $L^*(A,w,r,q,s)$, capital, $K^*(A,w,r,q,s)$, and land, $T^*(A,w,r,q,s)$. Farmers and workers are free to locate wherever they choose to maximize their income and provide a fixed quantity of labor, capital is supplied elastically through a nationwide capital market, the supply of land in each location is fixed, and energy is supplied in local markets with prices that may be regulated at state or regional levels.

When the REA gave farms access to electricity, it reduced the price of energy inputs (s), which is expected to increase the productivity of farms, which

[6] Since the REA and cooperatives largely electrified farms, we model the profit decisions of farms. Nonfarm firms in manufacturing, retailing, wholesaling and other activities can be modeled in this way but likely with different production functions, while the prices for factors of similar quality were likely to be similar across all economic activities because farms and nonfarm firms competed for labor, land, building, and some forms of capital within the same counties and nearby counties.

in turn leads to increased demand for labor. The demand for land is increased as farms are more productive and farmers wish to produce more output. This would attract new farmers and farm workers moving into the areas. The in-migration, would, in turn, require housing, which will add an additional boost to land prices where the supply of land is upward sloping. The substitution of electricity for coal, wood, or steam power leads to decreases in these energy prices. To hire more workers to relocate to the area in a regular market, we would expect farm wages to rise and wages in manufacturing and retail to rise as the employers try to prevent them from moving out.[7] However, the high levels of unemployment and the large number of people working less than full time in the 1930s would likely dampen the wage effects (Fishback, Haines, Rhode 2012; Cole and Ohanian 2004, Taylor 2011). Capital is assumed to be traded in a national market so that local conditions do not impact the price of capital.

The input prices depend on access to the REA. The productivity parameter, the wage, the land price, and the electricity price are allowed to depend on access to the REA. By the mid 1920's most states had adopted regulatory commissions, which often set state-wide upper bounds on electric rates (Stigler and Freidland 1962). These rural locations did not previously have access to

[7] We ignore the amenities effect on workers. If electricity does improve amenities, then even more workers would be willing to relocate to REA served areas, likely leading to smaller increases in wages in the rural location, and possibly larger wage increases in the urban location.

electricity, so improved access to electricity would likely decrease local prices. To summarize all of the comparative statics, it is instructive to examine the change in short run profits of an incumbent farm as a result of increased access to electricity via the REA.

The short run equilibrium profits for an incumbent farm can be written in terms of the optimal level of inputs and their corresponding prices as well as the access to the REA, where we denote access to the REA with the variable R.

(2)
$$\pi = f\begin{pmatrix} A(R), L^*\big(A(R), w(R), r, q(R), s(R)\big), K^*\big(A(R), w(R), r, q(R), s(R)\big), \\ T^*\big(A(R), w(R), r, q(R), s(R)\big), E^*\big(A(R), w(R), r, q(R), s(R)\big) \end{pmatrix}$$
$$- w(R)L^*\big(A(R), w(R), r, q(R), s(R)\big) - rK^*\big(A(R), w(R), r, q(R), s(R)\big) - qT^*\big(A(R), w(R), r, q(R), s(R)\big) - sE^*(A(R), w(R), r, q(R), s(R))$$

To see how the short run profits of the incumbent farm change when farms gain access to the REA, we take the total derivative of profits with respect to access to the REA loan program. Differentiating with respect to access to the REA and collecting terms yields the following relationship for farm profits.

(3)
$$\frac{d\pi}{dR} = \left(\frac{df}{dA}\cdot\frac{dA}{dR}\right) + \frac{dA}{dR}\left\{\left[\frac{dL}{dA}\left(\frac{df}{dL} - w\right)\right] + \left[\frac{dK}{dA}\left(\frac{df}{dK} - r\right)\right] + \left[\frac{dT}{dA}\left(\frac{df}{dT} - q\right)\right] + \left[\frac{dE}{dA}\left(\frac{df}{dE} - s\right)\right]\right\} + \frac{dw}{dR}\left\{\left[\frac{dL}{dw}\left(\frac{df}{dL} - w\right) - L^*\right] + \left[\frac{dK}{dw}\left(\frac{df}{dK} - r\right)\right] + \left[\frac{dT}{dw}\left(\frac{df}{dT} - q\right)\right] + \left[\frac{dE}{dw}\left(\frac{df}{dE} - s\right)\right]\right\} + \frac{dq}{dR}\left\{\left[\frac{dL}{dw}\left(\frac{df}{dL} - w\right)\right] + \left[\frac{dK}{dw}\left(\frac{df}{dK} - r\right)\right] + \left[\frac{dT}{dw}\left(\frac{df}{dT} - q\right) - T^*\right] + \left[\frac{dE}{dw}\left(\frac{df}{dE} - s\right)\right]\right\} + \frac{ds}{dR}\left\{\left[\frac{dL}{dw}\left(\frac{df}{dL} - w\right)\right] + \left[\frac{dK}{dw}\left(\frac{df}{dK} - r\right)\right] + \left[\frac{dT}{dw}\left(\frac{df}{dT} - q\right)\right] + \left[\frac{dE}{dw}\left(\frac{df}{dE} - s\right)\right] - E^*\right\}$$

If inputs are purchased such that each input is paid its marginal product, then the previous expression simplifies to

$$(4)\ \frac{d\pi}{dR} = \left(\frac{df}{dA}\frac{dA}{dR}\right) - \frac{dw}{dR}L^{*} - \frac{dq}{dR}T^{*} - \frac{ds}{dR}E^{*}$$

Equation (4) shows that the REA affects farm profitability through four channels. Access to the REA increases profits through increased farm productivity, lowers profits by raising wages, decreases profitability by increasing land prices as farms and workers compete for land, raise profits as a result of lower energy prices. The overall impact on the REA is ambiguous because it is unclear if productivity gains and lower energy prices will be offset by more expensive labor and land. Therefore, empirical analysis of a variety of measures of farm and nonfarm activity is necessary to determine which effects are strongest.

4. Sample Construction

Data for the empirical exercise are derived from a variety of federal publications. Outcome and control variables come from Census publications compiled in Haines (2005) and a new agricultural dataset collected by Fishback, Haines, and Rhode (2013). Data pertaining to the value of REA loan contracts by county, as well as other New Deal Agency loans are from Fishback, Horrace, and Kantor (2005), which originally came from unpublished mimeos of the Office of Governmental Reports (1940). Information detailing the location of REA projects comes from the Report of the REA (1939). Because REA loan information at the county level is only available through 1939, the empirical exercise will focus on the period between 1935 and 1940, when the REA was most active in its loan program.

Data about the state of the electric grid prior to the formation of the REA is important in controlling for selection of projects based on access to the grid. The locations of the electric transmission grid and electric generation plants in 1935 come from the Federal Power Commission National Power Survey Interim Report Power Series No. 1 (1935) and were digitized using ArcGIS. The 1935 grid does not include power generated from new dams that were being built under the New Deal, like the TVA, because the projects were not generating electricity as of 1935.

Figure 1 displays the service areas of the REA funded projects as of 1939. Most of the projects were located in the Mid Atlantic, Southeast, Great Lakes, and Midwest; therefore, we restrict the sample to counties in these states.[8] The sample is restricted further to counties with populations under 20,000 as of 1930 to eliminate large cities, which were not eligible for funding under the REA

[8] The states left out of the sample are Alaska, Arizona, California, Colorado, Connecticut, Delaware, Washington DC, Hawaii, Idaho, Maine, Maryland, Massachusetts, Montana, Nevada, New Hampshire, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Utah, Vermont, Washington, and Wyoming.

guidelines. Of the approximately 3,000 counties in the United States, the restrictions leave 1,377 counties in the sample.

The summary statistics in Table 1 show that there were differences between the REA and nonREA counties before and after the REA was introduced. Despite having fewer urban areas, the REA counties had more people than the nonREA counties on average. Mean total output, measured as value of farm products, sold, traded, or used and then deflated by the wholesale price index for farm products was higher in the counties receiving REA loans in both 1929 and 1939, because there were more farms and output per acre was higher in the REA counties. These two factors offset the lower value of output per farm in the REA counties, which was driven by average acreage that was about one-fourth of the average in the nonREA counties. The farms in REA counties tended to have lower shares of value devoted to animal products while using a higher share of their production on their own farm. The levels of inputs also varied some, as farms in REA counties had higher land and building values (deflated by the wholesale price index for farm products) and lower values of farm machinery and implements (deflated by the wholesale price index for farm machinery) despite having less acreage. The farm operator worked fewer days off of the farm and used more family labor and less hired labor. Because of the lower share of population in cities of 2,500 or more and greater distance from larger urban areas, retail sales per capita, annual retail earnings, and manufacturing annual earnings were lower in the REA counties, although the number of manufacturing establishments were slightly higher in the REA counties. These differences in the features of the REA and nonREA levels of activity, led us to control for the starting level of key economic variables in the as well as to perform the placebo analyses below.

It is important to realize that the comparisons that follow here are made between a peak economy in 1929 and the situation in 1939 as the economy was still recovering from the ravages of the Great Depression. The counties that received REA loans were able to stave off many of the negative changes wrought by the Great Depression better than the counties that did not. The total value of farm products, the value per farm, and value per acre all fell in both types of counties between 1929 and 1939; however the REA counties experienced smaller declines. The value of crop output per farm actually rose for the REA counties while falling in the nonREA counties. Meanwhile, both types of counties produced a higher value of animal products and tended to use more of their output on their own farms with an average increase that was larger in the REA counties. The value of land and buildings per farm deflated by farm product prices fell by roughly the same amount in both types of counties, while the value of farm implements and machinery per farm fell much less in the REA counties. Farm operators in both REA and nonREA counties increased their average days worked off of the farm by nearly 30 days, but the rise was lower in the REA counties.

Between 1935 and 1939 farms in both types of counties used more hired labor and less family labor but the REA counties increased their use of hired labor less and reduced their use of family labor less. The population grew in both the REA and nonREA counties but grew by more people in the REA counties. The share of the rural farm population dropped in both counties but by less in the REA counties, suggest less movement off of the farm there. Retail sales per capita fell less between 1929 and 1939 in the REA counties. Meanwhile, alternative annual earnings moved in opposite directions. Annual retail earnings fell more in the REA counties but annual manufacturing earnings fell less, as did manufacturing value added per acre and the number of manufacturing establishments. These summary statistics show the associations between the REA and the various dimensions of economic activity, while the analysis below examines whether these same relative changes are present after controlling for a broad range of correlates and whether we can assign a causal role to the REA.

5. The Empirical Model

We examine the influence of the REA by using information on the dependent variables from two years, one before the REA was put into effect and another just as the first round of REA loans made between July 1, 1935 and June 30, 1939 had ended. The year prior to the REA year is either 1929, 1930, or 1935, while the REA year is either 1939 or 1940. For simplicity in the discussion of the empirical model we will use 1930 and 1940 to designate the two years. Had REA loans been randomly assigned, the average treatment effect of a REA loan can be estimated with the following ordinary least squares regression:

$$(5)\ \ \ln Y_{it} = \alpha_0 + \alpha_1 D40 + \beta_1 REA_{it} + \beta_{30} X_{i,30} + \beta_{40} X_{i,30} D40 + \beta_2 ND3339_{it} + \mu_i + \varepsilon_{it},$$

lnY_{it} is the natural log of the dependent variable in county i and year t—either 1930 or 1940. $D40$ is a dummy variable with value 1 in 1940 and zero in 1930. REA_{it} is the value of REA loans between July 1, 1935 and June 30, 1939 per farm in the county in 1967 dollars. The vector $X_{i,30}$ contains a variety of pre-treatment correlates measured prior to the introduction of the REA. We allow the pre-treatment correlates to have differential effects in 1930 and 1940 by interacting $X_{i,30}$ with the 1940 dummy, such that β_{30} measures the impact of the $X_{i,30}$ correlates in 1930 and β_{40} measures the difference in the impact of the same correlates in 1940. The baseline characteristics in a pre-treatment year are used rather than the levels of observed characteristics in 1940 because electricity is a general purpose technology, which likely affected many outcomes simultaneously. Therefore, for each outcome, the REA coefficient measures the sum of all of the effects on that outcome in 1940 that might have operated through a variety of outcome measures, while controlling for the prior levels of a variety of covariates. For instance, when examining the effect of the REA on manufacturing earnings, some of the REA effect may have come through its impact on the unemployment rate in 1939 or 1940. The coefficient captures the combination of the REA's direct effect on wages as well as its indirect effect through changes in unemployment, while taking into account the levels of both wages and unemployment (and any other potential outcomes of interest) at the beginning of the decade.

In addition, we control for grants and loans from other New Deal programs in the vector ND3339, so that we are not ascribing effects of the REA that actually were the result of other New Deal programs. The New Deal measures include Agricultural Adjustment Administration (AAA) grants per farm, Farm Security Administration (FSA) loans per farm, Farm Credit Administration (FCA) loans per farm, other non-farm New Deal grants per farm and other non-farm New Deal loans per farm. Finally, to control for time-invariant unobservable characteristics in the counties, a vector of county fixed effects, μ_i, has been added to the equation.

We estimate the model in first differences. After subtracting the equation for 1930 from the equation for 1940, and making adjustments, the final equation for estimation is

(6) $\ln Y_{i40} - \ln Y_{i30} = \alpha_1 + \beta_1 REA_{i3539} + \beta_{40} X_{i,30} + \beta_2 ND3339_i + \varepsilon_{i40} - \varepsilon_{i30}.$[9]

[9] The equation takes this final form because α_0, $\beta_{30} X_{i,30}$ and μ_i terms are the same in both years. Because *D40* is zero for the 1930 equation and one for the 1940

The equation takes this final form because α_0, $\beta_{30} X_{i,30}$ and μ_i terms are the same in both years. Because *D40* is zero for the 1930 equation and one for the 1940 equation, α_1 and $\beta_{40} X_{i,30}$ is the outcome of the first difference for the terms where *D40* appears. There were no REA loans or New Deal programs in 1930, so the first difference is the level value for the REA for 1935 through 1939 and the New Deal levels for 1933 through 1939. The model controls for potential endogeneity arising from pretreatment differences in the counties and time-invariant features of the counties, while also controlling for spending and loans in other New Deal programs.

After these controls are in place, our qualitative analysis of the REA decision process shows that the dominant factor determining the location of REA loans was the potential cost of distributing electricity, which was strongly correlated with the distance from the existing electricity grid. To control for this selection process, we include two additional covariates that strongly affected the cost of obtaining electric service, the distance to the nearest generation station and the distance to the nearest transmission line. Greater distance along distribution lines meant more load loss due to resistance in the transmission lines and thus greater cost of delivering electricity. The distances were constructed using

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equation, α_1 and $\beta_{40} X_{i,30}$ is the outcome of the first difference for the terms where *D40* appears. There were no REA loans or New Deal programs in 1930, so the first difference is the level value for the REA for 1935 through 1939 and the New Deal levels for 1933 through 1939.

geocoded maps from reports filed by the FPC in 1935, which report the locations of central service stations and transmission lines. Figure 2(a) shows the spatial distribution of the electric grid from 1935, and Figure 2(b) shows the digitization of the map. Diamond shaped markers represent the location of electric generation stations, while lines represent the location of transmission lines.

The REA explicitly included these costs as a major component of their decision to grant loans to applicants. Both the proximity to central electric stations and to large transmission networks influenced the costs of delivering electricity, and thus, the financial success of loan applicants. These costs potentially were very large; in 1935 the Federal Power Commission reported those distribution losses ranged from 10-40 percent of all power sales in the country (FPC 1935). In regressions of REA loans per farm as a function only of the two distance measures and a constant, a one standard deviation (OSD) increase in distance from a generation plant leads to a 0.12 standard deviation decrease in REA spending per farm. For an OSD increase in the distance from the transmission grid, REA spending per farm falls by 0.079 standard deviations. Combined, these variables explain 3.3 (R-Squared) percent of the variation in REA spending per farm.

Placebo Testing

To test the effectiveness of our design and control variables, we estimate a set of placebo regressions by examining changes in outcomes from 1920 to 1930, a period well before the creation of the REA, as a function of REA loans per farm. Evidence of sizeable and statistically significant relationships between the later REA loans and the changes in outcomes in the 1920s would suggest that we have not controlled well for the REA selection process and would suggest the presence of bias in the results for the 1930s that we estimate below. Because of data limitations, we are only able to perform placebo regressions for some of the outcomes measured here. Since the results consistently show the absence of a relationship between the REA loans and the 1920s changes in outcomes that can be measured, it seems likely that the results would be the same as for the other outcome measures.

In Table 2 we present the results from the placebo regressions with and without the control variables. Standard errors are presented in parenthesis and are clustered at the state level. The clustering reduces problems with inference that might arise from correlation of unobservables across counties within the same state. Column 1 reports the results without the inclusion of any covariates while Column 2 adds the full set of covariates.

In the estimates without controls in Column 1 of Table 2, the only statistically significant coefficients are for population and the average value of land and buildings per acre. In both cases, the coefficients have the opposite sign of the coefficients for those variables estimated in Table 3 below; therefore, the implied selection bias works against the direction found in Table 3. Once the correlates are included in the placebo regressions in column 2, none of the coefficients are statistically significant and the magnitudes in most cases are substantially smaller than for the coefficients estimated in the regressions in Table 3. When all of the placebo results are considered, they appear consistent with the view that selection bias in the distribution of REA loans is not a problem in the analysis.

The Impact of the REA

When discussing the impact of the REA, remember that population was growing in both types of counties, but a decade of Depression and slow recovery left the economies in the counties in the sample in worse shape than they had been in 1929. On most dimensions, except population and crop output, the REA loans were transforming the counties where they were received in an environment where nearly all counties had still failed to reach their 1929 levels by 1939. Thus, when we are discussing positive coefficients for the REA, in many situations we are describing a setting where the REA counties performed better relative to the nonREA counties at promoting recovery or staving off further declines.

The results in Table 3 show that the distribution of REA loans contributed to increases in the value of crop output, and helped offset declines in overall agricultural output and productivity per acre. Outside of agriculture the effects on the retail and manufacturing sectors were generally small. Each entry in Table 3 shows the coefficients for separate regressions using the value of REA loans per farm as the measure of REA access. Robust standard errors clustered at the state level are reported in parenthesis. We will focus on the results with the full set of pre-treatment controls in discussing the magnitudes of the effects since these estimates are less likely to be affected by omitted variable and endogeneity bias.

The trends in the summary statistics in Table 1 show that the total value of farm output declined between 1929 and 1939. The introduction of the REA into a county helped stave off this decline relative to the nonREA counties through a complicated set of interactions by stimulating the value of output per farm, and the value of output per acre. The most comprehensive measure of farm output is the real value of farm products sold, used, and traded per farm, which we deflated by the wholesale price index for farm products.[10] The authors of the 1940 Census considered this measure to be their closest approximation to gross farm income (U.S. Bureau of the Census 1943, 869). In Table 3 the coefficient of the REA

[10]The writers of the 1940 Census of Agriculture suggest that the value of farm products, sold, used, or traded was their closest estimate of gross farm income U.S. Census Bureau, 1943, volume III, 869. The Wholesale price index for farm products is series cc86 in Carter, et. al. (2006, 3-175 to 3-176).

loans per farm is 0.0004, which implies that a one dollar increase in REA loans per farm raised the total value of farm products, sold, traded, or used in the county by roughly 0.04 percent. The mean REA loan per farm in REA counties of $77 was associated with a change in the natural log of the value of farm output of 0.0308 log points, which can be compared with a decline in the mean log value of output of -0.13 log points in REA counties. This finding suggests that without the REA the mean natural log of the value of output would have fallen by -0.161 log points rather than the decline of -0.13 log points with the mean REA loan in place. Thus, the REA loan helped prevent an additional 23.9 percent decline that would have occurred without the loan.

The positive effect of the REA loans was driven largely by an increase in the value of farm products per farm and per acre, while having no statistically significant impact on the number of farms or farm size. Here again, the productivity increases associated with the REA worked to offset downward trends between 1929 and 1939. In the summary statistics for REA counties in Table 1 both the value of farm products, sold, traded or used per farm and the same value per acre fell by 5 percent between 1929 and 1939. The REA loan coefficients imply that the $77 average REA loan per farm was related to a rise of about 5.39 percent of the value of output per farm and per acre. The mean change in the value of farm products per farm in Table 1 was negative 5 percent. Thus, without the REA the value of output per farm likely would have fallen by 10.39 percent, or about 104 percent more than the decline that actually occurred. Similarly, the average REA loan per farm would have raised the value of farm products per acre by 3.08 percent compared with a drop in the mean value of 5 percent with the REA loan in place; therefore, the REA loan helped prevent an additional 60 percent drop in the mean value of farm products per acre. The impact of the REA on the value of farm products arise while controlling for the AAA grants per farm offered to farmers to take land out of production, which also were considered to have raised output per acre but encouraged larger farm sizes (Depew, Fishback, and Rhode, 2013). Meanwhile, the REA loans did not have statistically significant relationships with the changes in the natural number of farms or the average acreage per farm.

The REA loans were associated with increases in the value of output per farm across several dimensions, the value of crop output, the value of animal products, and the value of farm products used on the farmer's own farm. The summary statistics in Table 1 show that the total value of crops, the value of crops per farm, and the value per acre all rose in the REA counties, while falling in the nonREA counties. We have two measures of the value of crops per farm. One is based on crop output figures multiplied by estimates of county prices, and the second is based on the farmers' answers to the questions about the value of crops sold or traded. Both are deflated using the wholesale price index for farm products. The coefficients in Table 3 suggest that the introduction of the mean

REA loan of $77 per farm would have accounted for 56.3 percent of the rise in mean total crop value in the REA counties, 34.4 percent of the rise in crop value per farm, and 108.7 percent of the rise in the value of crops sold or traded on the farm. The effect of the REA loan value per farm for the crop value sold or traded per farm is weaker and accounts for only 15.3 percent of the change in means over the decade, while the coefficient is not statistically significant.

The REA loans also were associated with increases in the real value of livestock products sold or traded per farm and in the per farm value of farm products used on the farmers' own farm. A move from no loan to the mean REA loan per farm contributed 19.1 percent of the rise in the mean value of livestock products sold or traded per farm and 10.1 percent of the rise in mean products used by the farmer on his own farm.

The REA's stimulus of the value of output per farm and per acre helped to offset a decline in the value of the land per acre and the value of land and buildings per acre between 1930 and 1940 in REA counties.   The Census reported estimates for both, but the agricultural reporters were not convinced that the separate estimates for the value of buildings and the value of land that they received were as good as the estimates of the combined value of land and buildings because the purchase price of most farms was the combined value of both land and buildings (U.S. Census Bureau, 1943, volume, p. 27.) The REA coefficients imply that the REA loans led to increases in both the value of land per acre and the values of land and buildings per acre that worked to offset the overall decline. In the absence of the average REA loan the mean natural log of the value of land and buildings per acre would have fallen by -0.2262 log points. This fall would have been 25.3 percent more than the actual 0.18 log point fall. The results for the natural log of the value of land per acre were similar; the REA loans helped the value of land on farms fall by only 0.22 log points percent rather than 0.266 log points.

One contributor to the positive relationship between REA loans and output per acre was an increase in the real value of farm implements and machinery per farm. The values were deflated by the Wholesale Price Index for farm machinery. The REA loans slowed a trend toward less use of machinery. Between 1930 and 1940 the mean natural log of the value of machinery per farm fell by 2 percent in the REA counties in Table 1. However, the REA loan coefficient for machinery shows that with no REA loans the mean value of machinery per farm would have fallen by 5.9 percent; thus, the REA loans staved off an additional decline that would have been 167.8 percent more negative than the actual decline.

The REA stimulus to farm activity led to one significant change in the use of labor inputs on farms. In counties receiving the average REA loan per farm, farm operators reduced the number of days they worked off of the farm by about

3 percent, which worked against a 30 percent rise in the mean days worked off the farm between 1935 and 1939. The REA loans possibly increased the use of family labor and hired labor on the farms, but the REA loan coefficient was statistically insignificant in each case.

Despite the rise in the real value of output per farm the REA loans appear to have had little impact on population change in the county. The REA loan coefficients in the population and net migration equations were positive, and the population coefficient implies that the mean REA loan would have contributed 27 percent of the rise in average population in REA counties, but none of the coefficients were statistically significant.[11]

The REA loans did have a positive effect on population through salutary effects on infant mortality. Table 1 shows that the REA counties experienced a 29 percent decline in the infant mortality rate between 1930 and 1940. This trend was similar in many counties throughout the U.S. The negative coefficient of -0.0005 implies that the REA helped account for 13.2 percent of the decline in

[11] In the migration equation we had to shift away from using the semi-log because net migration had a large number of negative values, and the log of a negative number is undefined. In addition we ran a cross-sectional regression rather than a difference regression because the net migration measure is a measure for the entire decade calculated as the change in population minus the natural increase in population, in which the natural increase is defined as births minus deaths. See Fishback, Horrace, and Kantor (2006) for more detail.

mean infant mortality rates in the REA counties. The REA loans were also associated with lower fertility rates but the effect was not statistically significant.

The effects of the REA on agriculture spilled over into increases in retail consumption that worked against the trend toward lower retail consumption between 1929 and 1939. The mean of the natural log of real retail sales per capita dropped by 0.43 log points in the REA counties between 1929 and 1939 The REA had a statistically significant positive impact that would have pushed against this trend by 0.031 log points. The rise in retail sales per capita associated with the REA loans did not lead to higher annual earnings on retail sales. The REA coefficient in the real annual retail earnings regression was negative and statistically significant and contributed about 11 percent to the decline in retail annual earnings between 1929 and 1939 in the REA counties.

In manufacturing the REA loans were associated with increased numbers of firms and possibly higher average annual earnings and value added per worker. The changes in means in the REA counties between 1929 and 1939 suggested sharp drops in manufacturing activity. The introduction of the REA helped to counteract these trends somewhat but only the REA coefficient in the number of firms equation is statistically significant. At the mean level of REA loans per farm the REA stimulus would have been 3.9 percent, working against the decline of 38 percent between 1929 and 1939.

6. Discussion and Conclusion

The REA was different from many other electrification projects. First and foremost, it was a loan program that focused on the construction of distribution lines and connecting customers rather than direct investment in grid infrastructure and generation. It also worked closely with loan applicants to design a system that was financially successful to minimize the risk of default.

While it is difficult to measure the value of the in kind benefits that the REA provided applicants through improvements in state legislation, wholesale contract negotiations, management training, and engineering advise, it is possible to measure the interest subsidy. If cooperatives had been able to acquire loans privately, the interest rate would have been at least 6 percent; however REA loan interest rates were set at approximately 3 percent, to be amortized over 25 years (Slattery 1940).

The average REA loan contract was for a principal of $230,000 amortized over 25 years at an interest rate of approximately 3 percent, with monthly payments of $1090.69. The average farm mortgage rate was around 5 percent between 1935 and 1940, which would have led to monthly payments of $1,344.56. Assuming that farm cooperatives or commercial entities obtain the 5 percent interest rate, the ex ante interest subsidy at the time the REA loan was made would have been the difference in the present value of the two streams of 300 monthly payments when evaluated at 5 percent, or $43,389, which was 18.9

percent of the principal on the loan. The actual ex ante subsidy was lower to the extent that cooperatives and firms could obtain lower interest rates than for farm mortgages, but it might well have been higher and reached Slattery's estimates of 6 percent to the extent that the electrification projects were considered to be riskier. This ex ante subsidy is comparable in size to the ex ante subsidies for the purchase and refinance of one million nonfarm mortgages by the Home Owners' Loan Corporation (HOLC) found by Fishback, Rose, and Snowden (2013).

Ex post, the REA loans had a much better record of repayment than the HOLC loans. The HOLC ended up foreclosing on 20 percent of their refinanced nonfarm home loans, although the overall losses from the HOLC ended up at about 2 percent of the value of the loans refinanced. In contrast, almost all REA loans from the 1935 to 1939 period were repaid, minimizing the ex post costs to the government. As of December 31, 1942, three percent of borrowers were behind on interest payments, 0.7 percent were behind on principal payments, while 37 percent of loans had been repaid in full, and another 53 percent were ahead of schedule on principal repayments (REA 1943).[12] This contrasts with figures for the HOLC in which one-third or more of borrowers were more than 3 months behind on principal and interest payments as late as 1940, seven years after the start of that program. Given the speed at which loans were repaid, and

[12] As of 1960, less than 1 percent of all REA loans were more than 30 days delinquent (NRECA 1960).

the relatively low default rates, the government's primary expenditure came through its engineering services, advising, and management training.

Conclusions

Electrification has been a central policy tool in developing countries as nations look to invest in infrastructure. Several nations are currently seeking billions of dollars to extend and make their infrastructure more reliable to attract firms and promote growth. We show here that the REA's extension of loans to cooperatives to electrify farms led to large productivity improvements in agriculture, which in turn led to increases in land values. To identify the effect of the REA on economic outcomes we use within county variation over time while controlling for selection by including measures of cost associated with access to grid infrastructure, and then performing placebo test that suggest a lack of selection bias.

We find that during the period 1930-1940, the introduction of the REA led to increases in agricultural productivity, which led farmers to seek employment off the farm less often, , increased property values, and reduced infant mortality. The REA made rural life more attractive by increasing productivity on the farm and improving amenities in the home. As developing nations introduce electric grids to urban and rural areas, there will be a spatial impact on the population as people move to take advantage of changes in wages and the standard of living associated with the newly constructed infrastructure. We believe that this study sheds light onto this policy debates to inform policy makers of ways to improve the lives of individuals living without electricity, particularly in rural communities.

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Tables and Figures

Figure 1: Service Area of Individual REA Funded Projects 1939

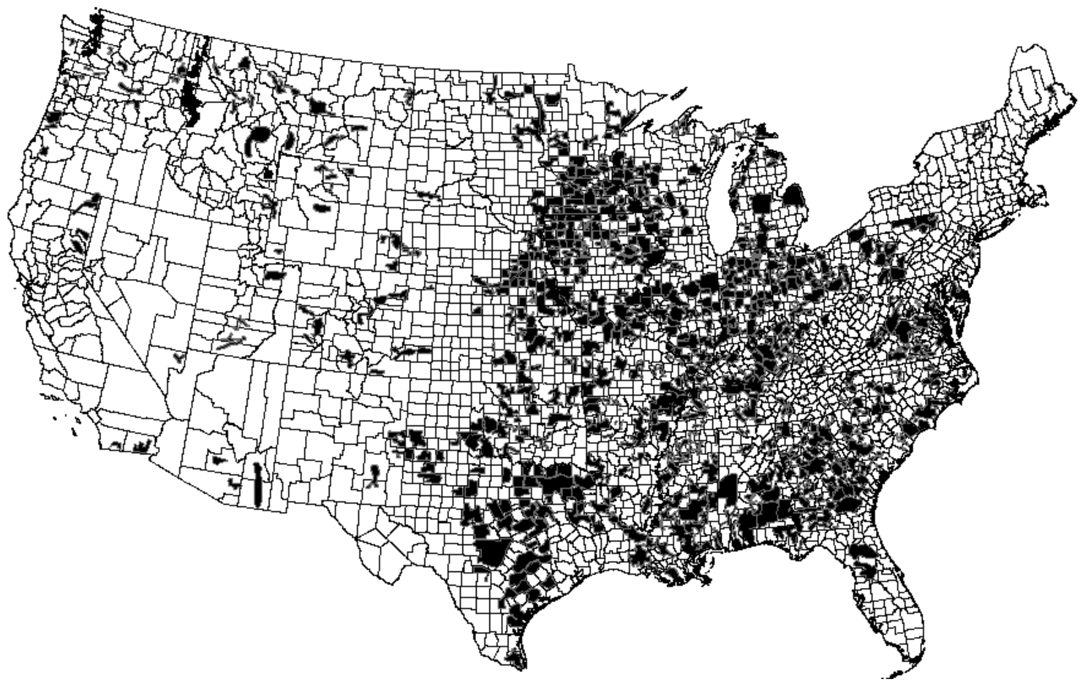
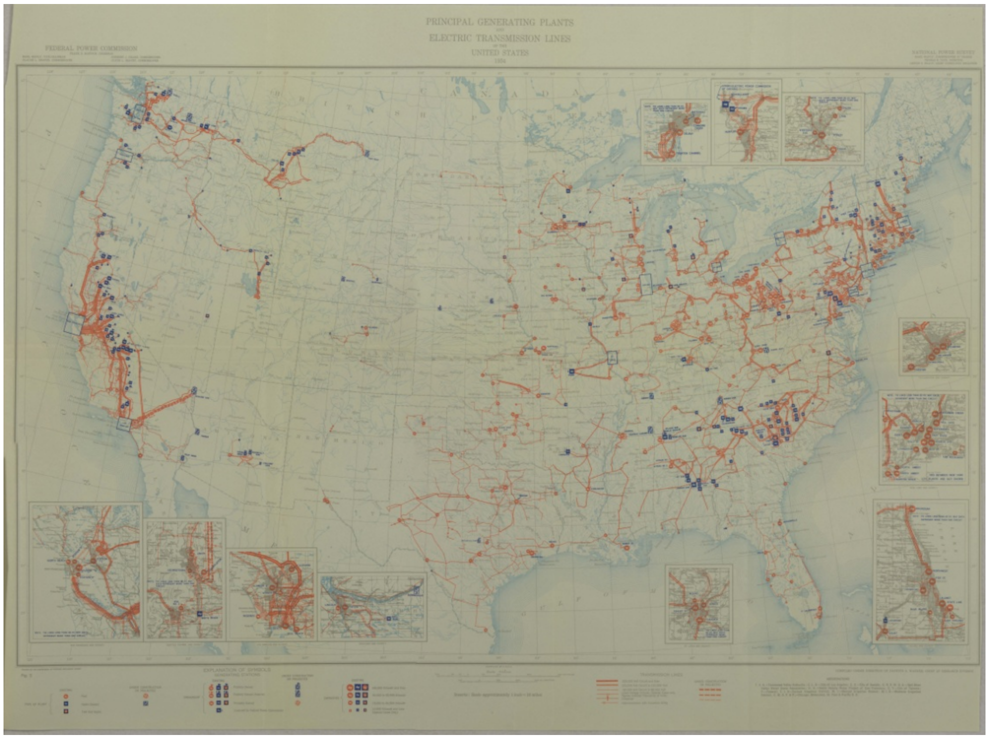
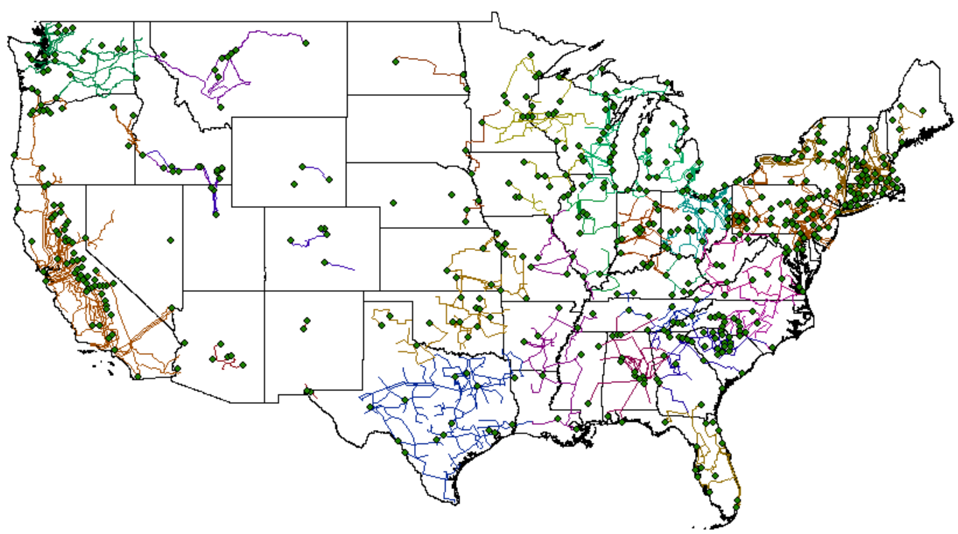


Figure 2: 1935 Electric Transmission Grid in United States



(a)



(b)

Table 1: Summary Statistics 1930-1940

	Difference 1930-1940 in Levels			Difference 1930-1940 in Logs		
	REA = 0	REA = 1		REA = 0	REA = 1	
	Mean	Mean	Diff-in-Diff	Mean	Mean	Diff-in-Diff
Crop Value per Farm 29-39	-221.91	218.56	440.47	-0.098	0.134	-0.232
Crop Value per Acre 29-39	-0.30	0.97	1.27	-0.193	0.057	-0.250
Crop Value (County Aggregate) 29-39	-251872.90	291766.60	543639.50	-0.129	0.096	-0.225
Value of Farm Products Sold, Traded or Used per Farm 29-39	-397.81	-42.07	355.75	-0.193	-0.052	-0.142
Value of Farm Products Sold, Traded or Used per Acre 29-39	-1.78	-1.29	0.50	-0.193	-0.051	-0.142
Value of Farm Products Sold, Traded or Used (Total) 29-39	-623387.70	-190492.70	432895.00	-0.287	-0.129	-0.158
Value of Farm Implements 30-40	-211.45	-32.86	178.59	-0.191	-0.023	-0.168
No. of Farms 29-39	-33.27	-54.94	-21.67	-0.029	-0.038	0.009
Average No. Days Worked Off Farm 35-39	32.82	28.25	-4.57	0.355	0.301	0.054
Number of Hired Laborers per Farm 35-39	0.09	0.04	-0.05	0.223	0.203	0.020
Number of Family Laborers per Farm 35-39	-0.23	-0.25	-0.02	-0.169	-0.170	0.001
Value of Land per Acre 30-40	-10.64	-10.50	0.14	-0.361	-0.217	-0.144
Value of Land and Buildings per Acre 30-40	-12.24	-11.85	0.39	-0.327	-0.182	-0.145
Percentage Rural Farmers 30-40	-4.19	-3.14	1.05	-0.077	-0.057	-0.020
Population 30-40	322.92	463.70	140.78	0.010	0.028	-0.018
Net Migration	-6.976	-5.234	1.742			
Infant Mortality Rate 30-40	-13.67	-13.81	-0.14	-0.227	-0.292	0.065
General Fertility Rate 30-40	-11.94	-9.44	2.50	-0.162	-0.116	-0.046
Retail Sales Per Capita 29-39	-100.92	-74.75	26.17	-0.492	-0.426	-0.066
Retail Annual Earnings 29-39	-209.25	-261.72	-52.47	-0.297	-0.355	0.058
Mfg. Avg Annual Earnings 29-39	-359.66	-326.65	33.02	-0.466	-0.453	-0.014
Mfg. Value Added Per Worker 29-39	-792.96	-689.72	103.24	-0.341	-0.328	-0.013
No. Mfg. Establishments 29-39	0.78	0.77	-0.01	-0.383	-0.376	-0.007
Value of Crops Sold or Traded per Farm 1930-1940	-116.17	229.64	345.80	0.003	0.252	-0.248
Value of Livestock Sold or Traded per Farm 1930-1940	252.95	91.36	-161.59	0.098	0.202	-0.104
Value of Farm Products Used per Farm 1930-1940	48.07	62.69	14.62	0.172	0.230	-0.058
Average Farm Size 1930-1940	61.22	15.01	-46.21	0.094	0.078	0.016
Number of Counties in NonMfg. Sample	580	759		580	759	
Number of Counties in Mfg. Sample	278	461		278	461	

Table 2: Placebo Regressions

	REA = REA Spending per Farm			
	No Controls		Controls	
Y = Ln(Y30) – Ln(Y20)	1		2	
Crop Value per Farm 19-29	-0.0004		0.0001	
	(0.0003)		(0.0002)	
Crop Value per Acre 19-29	-0.0003		0.0004	
	(0.0003)		(0.0003)	
Total Crop Value 19-29	-0.0004		0.0004	
	(0.0003)		(0.0003)	
Change in Farmland 1920-1930	-0.0001		0.0000	
	(0.0001)		(0.0001)	
Change in Number of Farms 1920-1930	-0.0001		0.0001	
	(0.0001)		(0.0002)	
Acres of Farm Land per Farm	0.0000		-0.0001	
	(0.0002)		(0.0003)	
Value of Implements and Machinery 1920-1930	-0.0005		0.0001	
	(0.0003)		(0.0001)	
Average Value of Implements and Machinery per Farm	-0.0005		0.0000	
	(0.0003)		(0.0001)	
Average Value of Land and Buildings per Farm	-0.0005		-0.0004	
	(0.0003)		(0.0003)	
Average Value of Land and Buildings per Acre	-0.0005	*	-0.0002	
	(0.0003)		(0.0002)	
Population	-0.0002	***	0.0000	
	(0.0000)		(0.0000)	
Number of Manufacturing Establishments	-0.0004		-0.0001	
	(0.0003)		(0.0003)	
Average Annual Earnings Manufacturing Workers	0.0002		0.0000	
	(0.0001)		(0.0001)	
Manufacturing Value Added per Worker	0.0003		-0.0001	
	(0.0002)		(0.0002)	

Note: Each entry in this table comes from a separate regression. Robust standard errors clustered at the state level are in parentheses. New Deal control variables are for the period 1933 through 1939: AAA Spending per farm, FSA and FCA Loans per Farm, New Deal Grants per farm and New Deal loans per farm. The other control variables are from 1920 (or other year) and are the distance from the nearest generation station, the distance from the transmission grid, population, number of farms, percent of the population illiterate, the percent black, percent foreign born, percent of acres operated by tenants, and crop value (1920).

Table 3: Main Results Y = Ln(Y40) – Ln(Y30)

	OLS	OLS	OLS Coefficient times $77 average for loans per farm	Change in Mean of ln(dependent variable) in REA counties	Change due to REA as percent of overall change
	1	2	3	4	col 3 as % col 4
Net Migration 30-40	0.0207	0.0078	0.6006		
	(0.0130)	(0.0062)			
CHANGE IN					
Percent Rural Farmers 30-40	0.0001	0.0000	0.0000	-0.06	0.0
	(0.0001)	(0.0001)			
CHANGE IN LOG VALUE OF					
Population 30-40	0.0001	0.0001	0.0077	0.03	27.4
	(0.0001)	(0.0001)			
Total Value of Farm Products Sold, Traded, or Used in County 29-39	0.0007 *	0.0004 *	0.0308	-0.13	-23.9
	(0.0004)	(0.0002)			
Number of Farms 29-39	0.0002	0.0001 *	0.0077	-0.04	-20.0
	(0.0001)	(0.0001)			
Value of Farm Products Sold, Traded or Used Per Farm 29-39	0.0009 **	0.0007 ***	0.0539	-0.05	-104.5
	(0.0004)	(0.0002)			
Value of Farm Products Sold, Traded or Used per Acre 29-39	0.001 **	0.0004 ***	0.0308	-0.05	-60.4
	(0.0004)	(0.0003)			
Acres per Farm, 29-39	-0.0003 **	-0.0001	-0.0077	0.08	-9.9
	(0.0001)	(0.0001)			
Average Value of Crops Sold or Traded 29-39	0.0016 **	0.0005	0.0385	0.25	15.3
	(0.0006)	(0.0004)			
Average Value of Livestock Products Sold or Traded 29-39	0.0003	0.0005 **	0.0385	0.20	19.1
	(0.0003)	(0.0002)			
Average Farm Products Used on Farmer's Own Farm 29-39	0.0001	0.0003 **	0.0231	0.23	10.1
	(0.0002)	(0.0001)			
Crop Value per Farm 29-39	0.0011 *	0.0006 **	0.0462	0.13	34.4
	(0.0006)	(0.0003)			
Crop Value per Acre 29-39	0.0015 **	0.0008 **	0.0616	0.06	108.7
	(0.0006)	(0.0003)			
Total Crop Value 29-39	0.0013 **	0.0007 **	0.0539	0.10	56.3
	(0.0006)	(0.0003)			

Value of Land per Acre 30-40	0.0004		0.0006	**	0.0462	-0.22	-21.3
	(0.0004)		(0.0003)				
Value of Land and Building per Acre 30-40	0.0005		0.0006	**	0.0462	-0.18	-25.3
	(0.0004)		(0.0003)				
Value of Farm Implements and Machinery per Farm 30-40	0.0007	*	0.0005	**	0.0385	-0.02	-167.8
	(0.0004)		(0.0002)				
Average No. Days Worked Off Farm by Farm Operator 35-39	-0.0005	**	-0.0004	**	-0.0308	0.30	-10.2
	(0.0002)		(0.0001)				
Number of Hired Laborers per Farm September 1939 minus January 1935	-0.0003		0.0001		0.0077	0.20	3.8
	(0.0004)		(0.0003)				
Number of Family Working on Farm per Farm September 1939 minus January 1935	0.0004	**	0.0002		0.0154	-0.17	-9.1
	(0.0001)		(0.0001)				
Infant Mortality Rate 30-40	-0.0008	***	-0.0005	*	-0.0385	-0.29	13.2
	(0.0003)		(0.0002)				
General Fertility Rate 30-40	0.0001		-0.0001		-0.0077	-0.12	6.6
	(0.0002)		(0.0001)				
Retail Average Annual Earnings 29-39	-0.0006	**	-0.0005	*	-0.0385	-0.35	10.8
	(0.0003)		(0.0003)				
Mfg. Avg Annual Earnings 29-39	0.0001		0.0002		0.0154	-0.45	-3.4
	(0.0002)		(0.0002)				
Mfg. Value Added Per Worker 29-39	0.0001		0.0006		0.0462	-0.33	-14.1
	(0.0004)		(0.0005)				
No. Mfg. Establishments 29-39	0.0009	**	0.0005	*	0.0385	-0.38	-10.2
	(0.0004)		(0.0002)				
Retail Sales Per Capita 29-39	0.0007	***	0.0004	***	0.0308	-0.43	-7.2
	(0.0002)		(0.0001)				

Note: Each entry in this table comes from a separate regression. Robust standard errors clustered at the state level are in parentheses. New Deal control variables are for the period 1933 through 1939: AAA Spending per farm, FSA and FCA Loans per Farm, New Deal Grants per farm, and New Deal loans per farm. The number of farms and population are from 1930. The other control variables are from 1930 (or other year) and are the population, percent in manufacturing of gainful workers, number of farms, percent of the population illiterate, the percent unemployed, the number of farms, the percent black, percent married, percent divorced, percent foreign born, percent of acres operated by tenants, per capita crop value (1929), and percent owning a radio.