Fertility, child health, and the diffusion of electricity in the home*

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Preliminary - Please do not cite

July 23, 2012

*I am grateful to Dwayne Benjamin, Rob McMillan, Aloysius Siow, and Mark Stabile for their guidance and supervision during this research. I also benefited from valuable comments from Stephania Albanesi, Martha Bailey, Andrew Bird, Gustavo Bobonis, Branko Boskovic, Leah Brooks, Victor Couture, Shari Eli, Gillian Hamilton, Sacha Kapoor, Kory Kroft, Frank Lewis, Hugh Macartney, Valerie Ramey, Matthew Turner, and seminar participants at the University of Toronto. I also thank Martha Bailey and William Collins for generously providing data on appliance ownership and electrical services. I gratefully acknowledge financial support from SSHRC and the Royal Bank Graduate Fellowship in Public and Economic Policy. All omissions and errors are my own.

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Abstract

How did access to electricity and modern household appliances affect families in the US? Guided by historical evidence that modern household technology saved time on housework and offered direct health benefits, I study the effects of electricity and modern appliances focusing specifically on the tradeoff between quantity and quality of children. The empirical analysis exploits large cross-county and cross-state variation in the timing of diffusion of electricity and modern appliances for the period 1930 to 1960. In the baseline models, I relate changes in the proportion of households with electricity or modern appliances to changes in fertility rates, school attendance, and infant mortality. The fact that the decision to purchase a modern appliance may have been correlated with unobservable family characteristics creates a challenging identification problem, which I address using a new dataset of the US power grid. This dataset provides information on the construction of over 1600 new power plants throughout the period. Identification relies on plausibly exogenous changes in the cost of supplying power to different communities based on their location. I find that modern household technologies led families to make a quantity-quality tradeoff in terms of children: modern appliances were associated with increases in early school attendance, decreases in infant mortality, and declines in fertility. The declines in infant mortality were particularly large in states that relied heavily on coal for heating and cooking, consistent with modern stoves directly reducing indoor air pollution. Meanwhile, health improvements were larger in states that had previously invested heavily in maternal education programs, suggesting that household modernization also led parents to provide better infant care. The results do not appear to have been driven by local economic development or changes in the quality of local health care. This analysis adds to our understanding of the causes of the dramatic health improvements throughout the first half of the 20th century, and provides insight into the benefits of investment in electricity infrastructure in developing countries.

1 Introduction

Technological change within the home has been identified as one of the major developments of the 20th century (Greenwood et al., 2005a, 2005b; Schwartz Cowan, 1983; Strasser, 1982). These changes were profound: in 1930, over 60% of homes lacked electricity or were wired only for basic lighting (Tobey, 1996, pp.35), and few families owned a single major modern appliances.[1] By 1960, virtually all families resided in homes equipped with electric lights, running water, and a variety of modern appliances.

How did the 'household revolution' affect families? Electricity and labour-saving appliances dramatically reduced the burden of basic housework, and freed up enormous amounts of time.[2] Despite a growing literature, there is little consensus on how the substantial time-savings afforded by modern appliances affected families. In an influential paper, Greenwood et al. (2005a) argue that modern appliances led to the baby boom, as families had more time to allocate towards child-rearing. However, Bailey and Collins (2009) find that increases in household electrification and appliance ownership were actually associated with declines in fertility across the US, and that the Amish - a group that did not adopt modern technology - also experienced a baby boom. It has also been hypothesized that the reduced demands of housework allowed women to enter the labour force (Greenwood et al., 2005b), but these results have also not been borne out in the data (Cardia, 2011).[3]

A number of researchers argue that labour-saving appliances did not actually lead women to reduce the amount of time spent in home production (Vanek, 1973; Schwartz Cowan, 1983;

[1]Less than 30% of households owned a vacuum, 20% owned a washing machine, 5% owned a refrigerator, and just 2% owned an electric stove (Tobey, 1996, pp.7).

[2]Time-use studies conducted prior to household electrification provide insight into the benefits of household modernization. A 1901 survey from Massachusetts reported that women spent almost one hour per day in the care of a coal fire stove, and carried over 40 pounds of coal per day (Strasser, 1982, pp.41). Meanwhile, a single load of laundry could take nine hours to wash and iron (Greenwood et al., 2005b). Without electricity to pump water into homes, rural housewives typically hauled between 25 and 40 gallons of well-water per day (Caro, 1982, pp.513; Greenwood et al., 2005b). Although speculative, some accounts suggest that modern appliances offered a 4-person family almost 20 hours per week in time-savings on housework (Greenwood and Seshadri, 2005).

[3]Dinkelman (2011) does find a positive effect of rural electrification on female labour force participation in South Africa. These findings may have differed from the US because rural South Africa had a larger informal employment sector, which potentially reduced the barriers to entry into the labour force.

Strasser, 1982). In a comprehensive analysis of time-use studies from this period, Francis and Ramey (2009) estimate that total housewife time spent in home production fell by just 1.5 hours between 1930 and 1960. One explanation for this surprising result is that electricity and modern appliances reduced the burden of basic housework allowing families to devote more time towards better household hygiene practices and the care of children (Mokyr, 2000).[4] Consistent with this hypothesis, Ramey (2009) finds that housewives reduced the time spent on food preparation and laundry, despite having spent the same overall amount of time in home production. A key implication of this argument is that modern appliances should have led to increases in home production *output* (Ramey, 2009). If modern appliances allowed parents to devote more time to household hygiene practices and infant care, then these goods should have generated improvements in health-related outcomes.

In addition to the labour-saving benefits afforded by modern appliances, household modernization may have directly contributed to improved household health. Modern stoves replaced coal or wood fire stoves, reducing exposure to indoor air pollution (Luxton, 1980; Barreca, Clay, and Tarr, 2012).[5] Modern refrigerators reduced exposure to food-borne bacteria, particularly in milk and meat (Meckel, 1990; Mokyr, 2000). Refrigeration also expanded the variety of the American diet (Nickles, 2002; Meckel, 1990).[6] Finally, new building codes - established to ensure the safe wiring of homes - reduced substandard housing by imposing regulations on household ventilation, indoor toilets, and plumbing (Tobey, 1996).

This paper investigates the effect of electricity and modern appliances, focusing specifically on the tradeoff between the quantity and quality of children.[7] To fix ideas, I write down

[4]This period coincided with increased parental focus on basic health-promoting activities, such as breastfeeding, boiling of milk, and hand washing (Ewbank and Preston, 1989). Information campaigns in the early 20th century ensured that women were well-aware of the importance of their role in disease prevention (Ewbank and Preston, 1989; Moehling and Thomasson, 2012).

[5]Cooking with solid fuels produces pollutants such as particulates and carbon monoxide, and solid cooking fuels are currently the second leading worldwide environmental cause of death (Bruce et al., 2006). Historically, the hazards of indoor air pollution were exacerbated by concerns about thermal efficiency, which led homes to be made as airtight as possible (Strasser, 1982).

[6]Between 1930 and 1960, there was a substantial increase in the national consumption of meat and frozen foods and a corresponding decrease in flour and corn-based foods (Historical Statistics of the US, 1965).

[7]In the empirical analysis, infant mortality and school attendance are used to proxy child quality.

a Beckerian model of household production. Modern household technology should have led to improvements in child quality. By reducing the burden of basic housework, modern appliances freed up parental time, which could then be allocated towards child investment.[8] In addition, modern household technology directly contributed to improved household health, for example, by reducing indoor air pollution or exposure to food-borne bacteria. In fact, these direct effects of modernization could have spurred additional parental investments in child quality, creating a multiplier effect.[9] The relationship between household modernization and fertility is unclear. On the one hand, appliances freed up to time which could have been allocated towards raising more children. On the other hand, the direct health benefits associated with modern household technology created an incentive for parents to invest more time *per* child, which would have tended to decrease fertility.

In the empirical analysis, I investigate the relationship between household modernization, fertility, infant mortality, and school attendance. The analysis exploits large cross-county and cross-state variation in the timing of the diffusion of electricity and modern appliances between 1930 and 1960. In the baseline models, I relate changes in proportion of households with electricity or modern appliances to changes in fertility rates, school attendance, and infant mortality.

There are several major challenges to the empirical analysis. First, the fact that the decision to purchase a modern appliance may be correlated with unobservable family characteristics could lead to biased estimates. For example, increases in wealth may simultaneously have led a families to buy modern appliances and devote more resources towards child health, which would lead the estimates to be upward biased. Second, electrification rates and appliance-ownership rates may be a poor reflection of the true state of household

[8]Child investment is defined broadly to include any activity that generated improvements in child quality.

[9]A growing empirical literature suggests that health endowments and parental investments are complementary in the production of health capital (Aizer and Cuhna 2012; Bleakley, 2007). If so, a 'direct' improvement in child health should stimulate greater health investments by parents. Cutler and Miller (2005) find evidence that suggests that clean water technologies stimulated better personal health practices, consistent with this multiplier effect.

modernization.[10] Measurement error in the independent variables could lead the estimated coefficients to be biased towards zero.

To address these identification issues, I construct a new data set of the rollout of the US power grid. Using historical maps from the Federal Power Commission, I create a panel dataset covering the construction of over 1600 power plants between 1930 and 1960. This dataset provides information on power plant characteristics as well as detailed information on the location of each plant. The empirical approach is based on plausibly exogenous variation in the cost of providing power to different communities, based on the construction of new power plants throughout this period. Identification relies on the fact that power companies were more likely to supply electricity to communities that were near a power plant.[11] The exclusion restrictions require that the decision about where to locate a power plant plant was made independently of time-varying household characteristics, such as household income. Given extensive geographical constraints on where power plants could be built, their long lifespan, and historical evidence on how particular sites were chosen, the location of a power plant should have been exogenous to the main outcomes of interest.[12] I estimate instrumental variables (IV) regressions, using changes in county-distance to power plants as an instrument for household electrification and appliance ownership.

The main results suggest that household modernization led families to make a quantity-quality tradeoff in children. Electricity and modern appliances were associated with increases in early school attendance, decreases in infant mortality, and decreases in fertility. These findings are robust to the inclusion of a variety of demographic controls, and alternative estimation strategies. The estimates also do not appear to have been driven by local economic

[10] A better proxy for household modernization could be constructed as an index of the diffusion of all relevant modern appliances; however, consistent data are not available. Meanwhile, substantial changes in appliance quality throughout this period further complicate the analysis. Household electricity, although homogeneous across time and different regions, may also be a poor proxy for actual ownership of modern appliances.

[11] This pattern is strongly supported by the data (see Section 6.1), and is consistent with historical accounts of power transmission throughout this period (Hughes, 1993; *Electrical World*, Jan. 13, 1940).

[12] For example, the decision about where to build a hydroelectric plant was made to maximize the total electric capacity - by choosing a location with an adequate gradient - while minimizing dam construction costs. The importance of these factors overwhelmed concerns about transmission costs (Lovell, 1941).

development, cross-county migration, or changes in the quality of local health care.

Next, I examine *how* modern household technology led to improvements in child quality. The weight of the evidence suggests that child health improved both as a direct result of modern household appliances, and because of changes in parental investments. Modern household technology appears to have reduced indoor air pollution: improvements in household technology led to larger declines in infant mortality in states that were initially more reliant on coal for cooking and heating. Meanwhile, household modernization also led to greater parental investment in children: the declines in infant mortality were larger in states that had previously invested heavily in maternal health education programs - where mothers were most aware of better home health practices and the benefits to these activities.[13]

I conclude the empirical analysis by investigating whether electricity and modern appliances had other effects on families. I find no evidence that modern home technology led to an increase in female employment or had any effect on the timing of marriage. Household modernization did affect the composition of households: young couples were significantly less likely to reside with a parent, and older women were less likely live with an adult child. These results could reflect the fact that modern appliances reduced the burden of housework, allowing young mothers to care for family members without additional help from a parent.

This paper contributes to our understanding of the 'household revolution' in the US. The conceptual framework provides intuition as to why the dramatic time-savings afforded by modern appliances did not induce women to enter the labour force or generate increases in fertility,[14] and the empirical analysis suggests that the primary outcome of the 'household revolution' was healthier and better educated children. This research also adds to our understanding of the dramatic declines in infant mortality throughout the first two-thirds of the 20th century, and provides some of the first empirical evidence for arguments that

[13]One interpretation of this result is that educated families were more aware of the importance of investing in child health, so when they adopted modern technology, they were more likely to reallocate time towards children. Another interpretation is that these mothers had a better understanding of *how* to promote child health, so that a given level of investment was more productive.

[14]By raising the returns to child investment, parents had an incentive to allocate more time per child, at the expense of these other activities.

improvements in home sanitation and disease-prevention practices played an important role in the declines in infant mortality during this period (Ewbank and Preston, 1989; McKeown, 1976).[15]

The paper proceeds as follows: Section 2 provides some history of infant mortality and the diffusion of modern appliances into the home, Section 3 presents the conceptual framework, Section 4 presents the empirical strategy, Section 5 describes the data, Section 6 reports the empirical results, Section 7 reports a variety of robustness tests, Section 8 explores the channels through which modern household technology affected child health, Section 9 examines other effects of modern household technology, and Section 10 concludes.

2 Historical context

2.1 Longevity and infant mortality between 1900 and 1960

In 1900, life expectancy in the US was 47 years; by 1960, it was 70 years (Historical Statistics of the United States, 1965). Substantial reductions in infant mortality were a major driver of these increases in longevity. Between 1900 and 1960, infant mortality fell by more than 80% (Historical Statistics of the United States, 1965), and declines in infant mortality alone can explain almost one-third of the gains in life expectancy during this period (Cutler and Meara, 2001).

There is a growing literature on the determinants of infant health during this period. Improvements in socioeconomic status contributed to the reduction in infant mortality. Rising income levels allowed families to live in less crowded homes, which decreased exposure to infectious illnesses (Costa, 1997). Increased income also led to improvements in nutrition. Better-fed individuals are more resistant to many bacterial diseases, and recover more quickly (Cutler, Deaton, Lleras-Muney, 2006). Fogel (2004) argues that rising incomes led

[15] Recent research by Moehling and Thomasson (2012) also demonstrates the role of maternal education programs in reducing infant mortality.

to substantial increases in caloric intake, which led to reductions in mortality throughout the 19th and 20th century.[16]

Beginning in the late 1930s, advancements in medicine also played a role in the health improvements. The introduction of sulfa drugs in 1936 led to a 2-4% decline in overall mortality between 1937 and 1943 (Jayachandran et al., 2010). The discovery of a number of new vaccines had a smaller impact on mortality, primarily because vaccinated illnesses represented a minor fraction of the total mortality burden (Cutler, Deaton, Lleras-Muney, 2006).[17]

Public health initiatives, such as infrastructure investments in water and sewer systems led to major reductions in infant mortality in urban areas. Clean water was responsible for nearly three-quarters of the declines in infant mortality in major cities during the first three decades of the 20th century (Cutler and Miller, 2005).[18]

Despite this research, a large fraction of the declines in infant mortality and longevity gains throughout this period remain unexplained. Rising income levels, and the associated improvements in diet, can account for only 20% of the increases in life expectancy between the 1930s and the 1960s (Preston, 1975).[19] Improvements in water infrastructure - a primary factor in the declines in infant mortality throughout the first one-third of the 20th century - also cannot explain the substantial declines in infant mortality after 1930, when all major

[16]Other authors dispute importance of increased caloric intake for gains in longevity during the 20th century. Preston and Haines (1991) find that average daily caloric intake in 1900 was higher than it is today. Meanwhile, Preston (1996) argues that the positive relationship between height (a proxy for caloric intake) and longevity may not be causal. Instead, both height and mortality may have been the jointly determined by a common set of influences, such as the disease environment during childhood.

[17]Vaccines were discovered for rabies (1885), the plague (1897), diptheria (1923), tuberculosis (1927), tetanus (1927), yellow fever (1935), and polio (1955). Of these illnesses, only tuberculosis substantially contributed to the overall mortality rates. The BCG vaccine for tuberculosis also cannot account for the dramatic declines in tuberculosis mortality rates, since the vaccine was not adopted in the US (Feldberg, 1995).

[18]Ferrie and Troesken (2005) find that improvements in water infrastructure can explain between 30 and 50% of the decline in mortality in Chicago between 1850 and 1925.

[19]If economic growth alone were responsible for improved health, the relationship between health outcomes and income should be independent of time. This pattern is clearly rejected in the data. For example, in 2000, average income levels in China were similar to the US in the 1880s. However, the life expectancy in China in 2000 was roughly 30 years greater than it was in the US in the 1880s (Cutler, Deaton, Lleras-Muney, 2006; Historical Statistics of the United States, 1965).

cities already had clean water programs in place (Fox, 2012).

The existing literature also provides limited insight into the substantial declines in rural infant mortality throughout this period. Figure 1 reports total infant mortality and rural infant mortality and their difference for the years 1915 to 1970. Prior to 1930, total infant mortality declined more rapidly than rural infant mortality, as investment in clean water infrastructure eliminated the urban mortality penalty (Cutler and Miller, 2005). Since 1930, both urban and rural mortality rates declined at roughly the same rate. The large declines in rural infant mortality cannot be due to public investment in water projects, which were made in metropolitan areas. Similarly, advances in medicine disproportionately benefited individuals residing in urban areas, where families had better access to medical services (Jayachandran et al., 2010).

The diffusion of electricity and modern appliances into the home may also have contributed to the declines in infant mortality during this period. Modern household technology offered several direct benefits to child health. Refrigerators reduced exposure to food-borne bacteria, particularly in milk and meat (Meckel, 1990; Mokyr, 2000). Refrigerators also led to increased variety in the American diet (Craig et al., 2004; Meckel, 1990).[20]

Modern stoves stoves replaced coal or wood fire stoves, reducing exposure to indoor air pollution (Luxton, 1980; Barreca, Clay, Tarr, 2012). Cooking with solid fuels produces pollutants such as particulates and carbon monoxide, and solid fuels are currently the second leading environmental cause of death globally (Bruce et al., 2006). Among children, the primary health effect of indoor air pollution is an elevated risk and severity of acute respiratory infections, such as pneumonia (WHO, 2002). Historically, the risks of indoor air pollution were exacerbated by concerns about thermal efficiency, which led homes to be made as airtight as possible (Strasser, 1982).

[20]Prior to household electrification, meals were monotonous, and often had little nutritional content (Schwartz Cowan, 1983). In Tennessee and Georgia, corn made up 23% of total food consumption (Kirby, 1987). Between 1930 and 1960, there was a substantial increase in aggregate consumption of meat and corresponding decline in flour and corn based foods in the US, and frozen fruits and vegetables first entered the American diet (Historical Statistics of the United States, 1965).

Finally, electrification led to improvements in housing standards, which may also have contributed to better health outcomes. Beginning in 1934, the Federal Housing Administration (FHA) provided insurance for home-owners to borrow money to retrofit their homes for electric wiring or to purchase a major appliance.[21] To be eligible, a household had to meet a number of housing standards, such as proper ventilation, adequate natural light, and the availability of indoor plumbing and toilets (Tobey, 1996, pp.108-110).

In addition to these direct health benefits, electrification and modern appliances reduced the burden of basic housework, freeing up time for health-promoting activities and better infant care. Better home sanitation and disease-preventative practices have been identified as a source of the declines in infant mortality during this period (Ewbank and Preston, 1989; Meckel, 1990; Mokyr, 2000). Preston (1996) finds that between 1900 and the mid-1920s, the declines in child mortality were disproportionately large among families headed by physicians or teachers, consistent with the notion that new hygienic practices were first adopted by professional families. Moehling and Thomasson (2012) also find that maternal education campaigns funded by the Sheppard-Towner Act led to significant reductions in infant mortality during the 1920s.

The fact that labour-saving appliances might have caused families to reallocate time towards household hygiene and better infant care is not surprising. Prior to the diffusion of modern appliances, parents were made aware of the importance of their role in disease prevention.[22] Throughout the first few decades of the 20th century, information on infant care and hygiene practices was disseminated to mothers through popular magazines, educational pamphlets, motion pictures, and milk depots (Ewbank and Preston, 1989). From 1922 to 1929, the Sheppard-Towner Act funded a variety of maternal education programs, including one-on-one visits from nurses into homes (Moehling and Thomasson, 2012). The primary

[21] Between 1934 and 1937 roughly 1 in 8 households took advantage of this program.

[22] By the early 20th century, most experts believed that maternal behaviour was a critical determinant of infant health. An influential 1906 study stated, "it become clear that the problem of infant mortality is not one of sanitation alone, or housing, or indeed poverty as such, but is mainly a question of motherhood (Newman, 1906)."

message of these campaigns concerned proper feeding practices and home sanitation. Mothers were encouraged to boil bottles and milk, wash food, and protect food from flies. They were also advised to maintain home cleanliness and sanitation, encourage hand washing, isolate sick children, and ensure rooms were well-ventilated (Ewbank and Preston, 1989).[23]

Modern appliances offered both direct and indirect benefits to infant health, and may help explain the large declines in infant mortality between 1930 and 1960. These health benefits were particularly large in rural communities. Among rural families, electrification was far more likely to bring access to pumped water into the home, which dramatically reduced the time required for hygienic practices such as hand- and food-washing (Caro, 1982, pp.512). In addition, rural families were much less likely to use paid laundry services or domestic help,[24] so they disproportionately benefited from the time-savings afforded by modern appliances. Thus, household electrification may provide an explanation for the large declines in rural infant mortality during this period.

2.2 The diffusion of electricity and modern appliances into the home

Figure 2 displays the diffusion of electricity and modern appliances into the home between 1900 and 1970. Basic facilities, such as electricity and flush toilets, diffused gradually into the home beginning around 1920, and were essentially universal by 1960. The diffusion of modern appliances was much more rapid. Few families owned a single major appliance in 1930, however, by 1960, almost all families owned a modern stove, a refrigerator, and a washing machine.

[23]Advertisers for modern appliances also took advantage of this campaign in order to promote their products. Fox (1990) finds that between 30% and 40% of advertisements in the *Ladies Home Journal* mentioned how appliances would increase efficiency and allow women to meet better domestic-science standards. Advertisements for refrigerators stressed the importance of safeguarding food, and the white design of electric refrigerators was meant to contrast with wooden ice boxes (Nickles, 1992). Advertisements for electric vacuum cleaners also exploited fears over dirt and germs (see Figure 5).

[24]A 1923 time-use study from Oregon found that urban homes were four times more likely to use domestic help (Wilson, 1929).

Several factors limited the diffusion of modern appliances in the 1920s. First, power companies were responsible for the construction and maintenance costs of transmission lines, as well as the costs of connecting new customers to the grid (Hughes, 1993). Because average electricity consumption among domestic users often did not cover the carrying cost, private companies were reluctant to supply homes with power.[25]

Second, home owners were responsible for the costs of retrofitting homes for electricity.[26] Although equipping a home for basic lighting was inexpensive, heavy appliances were required to be on a separate circuit with larger wiring, and kitchen wiring needed to be waterproofed (Tobey, 1996, pp.28). In 1930, the cost of a "minimum standard" of wiring and fixtures was estimated to be $70 (*Electrical World*, 1931). Moreover, early electric appliances were expensive and frequently broke down.[27]

Figure 3 reports the proportion of homes wired for modern appliances and domestic electricity consumption. By the late 1920s, less than one-third of homes were wired for modern appliances, and the average electrified home used less than 40 kwh per month. Although the majority of urban homes had electric lighting by the end of the 1920s, few families owned labour-saving appliances.

The barriers to household modernization were eliminated in the 1930s. As industry demand for power declined, power companies turned to domestic consumers as a new source of revenue,[28]. Meanwhile, government and cooperative power projects provided electricity to rural consumers. The prices of both appliances and basic electricity rates fell substantially in the early 1930s, and new appliance models were more reliable (Tobey, 1996, pp.126). Federal programs, such as the FHA, also provided families access to low-interest loans to

[25] In the 1920s, few families owned major energy-consuming appliances, and power companies lost money on 40% of domestic customers (Tobey, 1996, pp.12-20).

[26] It did not become standard for new homes to be equipped for lighting and modern appliances until the 1930s (Tobey, 1996, pp.31).

[27] The National Electric Light Association estimated that the annual maintenance costs for a refrigerator were $24 in 1929 (Tobey, 1996, pp.26).

[28] A 1935 summary of the power industry stated: "Interest has centered in the home this year... Because of the depression, neither factory, store, nor office has presented a hopeful field for rapid development (*Electrical World* vol. 105, January 5, 1935).

retrofit homes and purchase new appliances.

With the elimination of these barriers to modernization, electricity and modern appliances diffused rapidly into many homes. By 1960, average electricity consumption per user was more than 300 Kwh per month, and most households owned several major electric appliances.

3 Conceptual framework

To investigate the effect of modern technology on fertility and child investment decisions, I introduce a Beckerian model of home production, where families make decisions of the quality and number of children. I consider a static framework, in which parents jointly optimize behaviour.[29] This simple framework, though clearly not realistic, captures the key forces driving investment and fertility decisions, and the main results hold under quite general conditions.

Households choose consumption, c, number of children, n, and investment, e, in child quality, q, to maximize utility

$$U = (1-\gamma)\ln c + \gamma[\ln n + \beta \ln q].$$

Child quality is determined by the following function:

$$q = q(\theta, e),$$

which depends on parental investment, e, as well as the general state of household health, θ.[30] Child quality is increasing in both its arguments, and parental investments and general health capital are assumed to be complements, so that $q_{\theta e}(\theta, e) > 0$ (Hazan and Zoabi, 2006; Bleakley and Lange, 2009). This condition requires that the marginal product of given

[29]The model abstracts from intra-household bargaining decisions, which are not relevant to the analysis.
[30]Families take θ as exogenous.

investment is greater for higher levels of household health.

A household is endowed with one unit of time, which can be spent either in market work, l, or raising children. Denote τ_F as fraction of the household's time endowment that is required to raise a child regardless of quality. Investment in children is also time-consuming. Denote τ_Q as the fraction of the household's time endowment that is required for each unit of investment.[31] Thus, the total time required to raise a child with a level of investment e is $\tau_F + \tau_Q e$. The household faces the following two budget constraints:

$$l + n[\tau_F + \tau_Q e] = 1, \quad \text{and}$$

$$c = wl + Y,$$

where w is the wage for market work, and Y represents either non-labour income or husband's earnings.

Next, I describe how household technology affects families. Let z denote the state of household technology, which is taken as exogenous.[32] I assume improvements household technology affect both the state of household health and the time-cost of child investment.

Assumption 1 *The impact of household technology, z:*

i) Household technology reduce the time-cost of child investment: $\tau'_Q(z) < 0$

ii) Household technology raises the level of household health: $\theta'(z) > 0$.

The first assumption describes the labour-saving aspect of modern household technology. As households acquire modern appliances, a given amount of time spent in home production generates a higher level of investment in children. The second assumption relates to the direct benefits of modern household technology, independent of parental investments.

[31] In other words, to make investment e in child quality, parents must spend $t = \tau_Q e$ units of time in child investment. Notice that τ_Q is the inverse of the productivity of time spent in child investment, since $e = \frac{1}{\tau_Q} t$.

[32] I abstract from the decision to modernize in order to correspond closely with the empirical analysis, which is based on exogenous variation in access to modern appliances rather than the endogenous decision to purchase appliances.

Rearranging the first order conditions from the maximization problem lead to two key equations governing the choices of fertility and child investment:

$$\frac{\tau_Q(z)}{\tau_F + \tau_Q(z) \cdot e} = \frac{\beta q_e(\theta(z), e)}{q(\theta(z), e)} \tag{1}$$

$$n = \frac{\gamma(w + Y)}{w[\tau_F + \tau_Q(z) \cdot e]} \tag{2}$$

Equations (1) and (2) jointly define unique functions for fertility, $n = n(\theta(z), \tau_Q(z), \tau_F, w, Y)$, investment, $e = e(\theta(z), \tau_Q(z), \tau_F, w, Y)$, and child quality, $q = q(\theta(z), e(\theta(z), \tau_Q(z), \tau_F, w, Y))$.

Equation (1) characterizes the optimal choice of e. The LHS of (1) is the ratio of the cost of an additional unit of investment in child quality to the cost of an increase in fertility. The RHS of equation (1) is the marginal rate of substitution between quality and quantity. The state of household health, $\theta(z)$, enters equation (1) through the marginal rate of substitution. The impact of $\theta(z)$ on child investment depends on the degree of complementarity in the health production function.[33]

Equation (2) characterizes the optimal choice of n. Fertility, n, and investment in child quality, e, are inversely related.[34] Notice that $\theta(z)$ does not enter equation (2) directly. Improvements in household health affect n only through e. When there is a high degree of complementarity between e and $\theta(z)$, fertility will tend to be negatively related to household health. For a given choice of e, a decline in $\tau_Q(z)$ lowers the time-cost of children, which will tend to increase fertility. On the other hand, a decline in $\tau_Q(z)$ will all raise optimal investment per child, making children more costly. The net impact of $\tau_Q(z)$ on fertility depends on which of these effects dominates.

[33]Formally, an increase in $\theta(z)$ will lead to an increase in e if and only if $\frac{\partial(q_e(\theta(z),e)/q(\theta(z),e))}{\partial\theta(z)} > 0$. This condition states that impact of parental investment, e, on child quality (in percentage terms) is increasing with level of household health, $\theta(z)$.

[34]Equation (1) also implies a negative relationship between fertility and wages, a pattern that has been well-documented empirically (Jones, Schoonbroodt, and Tertilt, 2008).

Now I derive how modern household technology affects child quality and fertility. In what follows, I assume sufficient curvature in the production function for child quality, $q(\theta(z), e)$, so that $\frac{\partial(q_e(\theta(z),e)/q(\theta(z),e))}{\partial\theta(z)} > 0$.[35]

Proposition 1 *The impact of household technology (z) on child investment (e), child quality (q), and fertility (n):*

(i) $\frac{\partial e}{\partial z} > 0$

(ii) $\frac{\partial q}{\partial z} > 0$

(iii) $\frac{\partial n}{\partial z} \lesseqgtr 0$ *according to* $\epsilon_{e,\theta}/(1 - \epsilon_{e,\tau_Q}) \gtreqless -\frac{\tau_Q'(z)}{\tau_Q(z)} / \frac{\theta'(z)}{\theta(z)}$

where $\epsilon_{e,\theta} = |\frac{\partial e}{\partial \theta}\frac{\theta}{e}|$ *and* $\epsilon_{e,\tau_Q} = |\frac{\partial e}{\partial \tau_Q}\frac{\tau_Q}{e}|$ *represent the elasticities of parental investment with respect to child health and the time-cost of investment, respectively.*

According to equation (i), improvements in household technology will unambiguously increase parental investment in children. Declines in the time-cost of child investment, $\tau_Q(z)$, will generate increases in investment. Meanwhile, improvements in household health, $\theta(z)$, raises the return to child investment for a given time-cost of investment.

Equation (ii) shows child quality to be strictly increasing in the level of household technology, z. An increase in z raises child quality through three distinct channels. First, it reduces the time cost of child investment, $\tau_Q(z)$, causing families to increase investments in child quality. Second, it directly improve household health, $\theta(z)$, which raises child quality independent of parental investments. Third, the improvements in household health lead to additional investment in child quality, given the complementarity in the quality production function.

The impact of household technology on fertility is ambiguous, and depends on the direction of the inequality in equation (iii). The LHS of this equation is increasing in both the elasticity of child investment with respect to health, $\epsilon_{e,\theta}$, and the elasticity of child investment

[35] The condition requires sufficient complementarity in the production function, and will hold with any constant returns to scale production function with an elasticity between e and $\theta(z)$ of less than 1 (Hazan, and Zoabi, 2006). Empirical evidence supports this strong complementarity between health endowments and parental investment (Aizer and Cuhna, 2012; Bleakley and Lange, 2009).

with respect to its time-cost, ϵ_{e,τ_Q}. When $\epsilon_{e,\theta}$ is large it is more likely that improvements in household technology will lower fertility, since the improvements in health will lead to large increases in child investment, raising the time-cost of each additional child. A higher ϵ_{e,τ_Q} will also make it more likely that increases in household technology will lower fertility, since the 'time-saving' benefits from home modernization will be primarily absorbed by increases in investment in quality.[36] Overall, if child investment is responsive to either the household health, $\theta(z)$, or the time-cost of investment, $\tau_Q(z)$, improvements in household technology are more likely to reduce fertility.

The right-hand side of the equation is the ratio of the proportionate change in time-savings to the proportionate change in household health resulting from an increase in household technology. When modern technology has no effect on health ($\theta'(z) = 0$), improvements in household technology unambiguously increase fertility.[37] An increase in the effect of household technology on health will make it more likely that the effect of technology on fertility will be negative. The health benefits associated with modern household technology will tend to offset the time-savings effects, as families substitute towards fewer, higher quality children.

The intuition for the results can be gleaned from Figure 6. Consider and increase in household technology from z to z'. The decline in τ_Q expands the budget constraint leading to an increase in both child investment (e) and fertility (n).[38] The increase in θ raises the slope of indifference curves, causing the household to substitute towards higher e and lower n. Whether fertility rises or falls depends on whether the relative size of these two effects.

[36] When $\epsilon_{e,\tau_Q} > 1$ improvements in household technology will lead to an unambiguous declines in fertility. In this case, the time-savings associated with a 1% decrease in $\tau_Q(z)$ would be offset by an increase in e of more than 1%, which raises the overall time-cost of an additional child. However, this situation will not arise if there is sufficient complementarity between $\theta(z)$ and e in the quality production function, $q(\theta(z), e)$. For example, if $q(\theta(z), e)$ is specified as a CES production function, ϵ_{e,τ_Q} will be less than 1 whenever the elasticity of substitution between $\theta(z)$ and e is less than 1. Empirical studies support this sort of complementarity (Aizer and Cuhna, 2012; Bleakley and Lange, 2009).

[37] This prediction is the same as those found in previous studies of household modernization that focus on the labour-savings aspects of modern appliances (see Greenwood et al., 2005b).

[38] n will rise whenever there is sufficient curvature in the indifference curves, so that the income effect dominates the substitution effect. This condition will be met whenever there is a high degree of complementarity in $q(\theta, e)$.

4 Empirical strategy

In the empirical analysis, I investigate the effect of improvements in household technology on fertility and child quality. From equations (1) and (2), I write down the choices of fertility, n_{it}, and child quality, q_{it}, as a function of household technology, z_{it}, where subscript i denotes a household and subscript t denotes the year:

$$n_{it} = n(\theta(z_{it}), \tau_Q(z_{it}); X_{it}, \Gamma_{it}) \tag{3}$$

$$q_{it} = q(\theta(z_{it}), e(\theta(z_{it}), \tau_Q(z_{it})); X_{it}, \Gamma_{it}). \tag{4}$$

The terms X_{it} and Γ_{it} denote vectors of observable and unobservable household characteristics. These vectors are meant to capture changes in household income (w_{it} and Y_{it}) and changes in the basic time-cost of child rearing (τ_{Fit}), as well as other time-varying determinants of fertility and child quality.

The estimation strategy exploits large cross-county differences in the diffusion of modern household technology. In the baseline analysis, I estimate equations (3) and (4) using decennial county-level data for the years 1940 to 1960.[39] Fertility is calculated as the number of infants per 1,000 women aged 15 to 44. Child quality is proxied by the proportion of children attending school, and the infant mortality rate. I use county-level information on the proportion of households with refrigerators, modern stoves, and electric lights to proxy the level of household technology, z_{it}. The vector of observable family characteristics, X_{it} includes time-varying controls for log population, population density, percent non-white, percent urban, and median years of schooling (Haines, 2004). Unobservable characteristics, Γ_{it} is proxied by a full set of year and county fixed effects, as well as an idiosyncratic error term. Here are the two estimating equations:

$$n_{it} = \beta_0 + \beta_1 z_{it} + \beta_2 X_{it} + \beta_3 Year_t + \beta_4 County_i + \epsilon_{it} \tag{5}$$

[39] Household-level data on appliance ownership and electrical services is not available for this period.

$$q_{it} = \gamma_0 + \gamma_1 z_{it} + \gamma_2 X_{it} + \gamma_3 Year_t + \gamma_4 County_i + u_{it} \quad (6)$$

The estimate of β_1 in equation (5) captures the net effect of household technology on fertility. Taking a first-order Taylor series expansion of equation (3) reveals that $\beta_1 = \left[\frac{\partial \bar{n}}{\partial \theta(z_i)} \cdot \theta'(\bar{z}_i) + \frac{\partial \bar{n}}{\partial \tau_Q(z_i)} \cdot \tau_Q'(\bar{z}_i)\right]$. The net effect of household technology on fertility is a combination of the 'direct health effect', $\frac{\partial \bar{n}}{\partial \theta(z_i)} \cdot \theta'(\bar{z}_i)$, and the 'time-savings effect', $\frac{\partial \bar{n}}{\partial \tau_Q(z_i)} \cdot \tau_Q'(\bar{z}_i)$. The first term is negative and reflects the fact that the direct health benefits of household technology will tend to lower fertility. The second term is positive and captures the fact that time-savings associated with modern household technology will tend to increase fertility. The sign of β_1 reveals which effect dominates.

The coefficient γ_1 captures the overall impact of household technology on child quality. A first-order Taylor series expansion of equation (4) reveals that household technology affects child quality through three distinct channels: $\gamma_1 = \left[\frac{\partial \bar{q}}{\partial \theta(z_i)} \cdot \theta'(\bar{z}) + \frac{\partial \bar{q}}{\partial e} \cdot \frac{\partial \bar{e}}{\partial \theta(z_i)} \cdot \theta'(\bar{z}) + \frac{\partial \bar{q}}{\partial e} \cdot \frac{\partial \bar{e}}{\partial \tau_Q(z_i)} \tau_Q'(\bar{z})\right]$. The first term, $\frac{\partial \bar{q}}{\partial \theta(z_i)} \cdot \theta'(\bar{z})$, is positive and reflects the fact that improvements in household technology directly benefits child health independent of parental investments. The second term , $\frac{\partial \bar{q}}{\partial e} \cdot \frac{\partial \bar{e}}{\partial \theta(z_i)} \cdot \theta'(\bar{z})$, is also positive and captures the fact parents will choose to invest more in healthier children. The last term, $\frac{\partial \bar{q}}{\partial e} \cdot \frac{\partial \bar{e}}{\partial \tau_Q(z_i)} \tau_Q'(\bar{z})$, is positive and captures the time-savings benefits associated with improvements in household technology. Since all three terms are positive, γ_1 should also be positive, and improvements in household technology should lead to increases in child quality.

4.1 The rollout of the US power grid and household technology

In the baseline estimation strategy, I rely on a fixed-effects framework to identify the effect of household modernization on fertility and child quality. There are several reasons why this approach may yield biased estimates. First, the decision to purchase a modern appliance could have been endogenous. Unobservable characteristics, such as changes in local economic conditions, could simultaneously influence the decision to purchase a modern appliance and child outcomes. Although it was inexpensive to install basic lighting, private power companies had an incentive to provide power to wealthy households who were more likely to buy electric appliances and consume large amounts of energy (Tobey, 1996, pp.12-20). Thus, estimation based on ownership of electric lights suffers from a similar sort endogeneity. Second, ownership of specific appliances may be a poor proxy for the actual state of household technology. Measurement error in these independent variables could cause the estimates to be biased towards zero.

To address these concerns, I construct a new data set of the rollout of the US power grid. I use a series of seven maps constructed by the Federal Power Commission in 1962. The maps identify the exact location of all power plants in the US, along with information on ownership (private, federal, state, municipal, or cooperative), capacity (in megawatts), and type of facility (hydroelectric, internal combustion, or steam). Figure 7 presents a subsection of one of these maps. Each numbered circle or square corresponds to a particular power plant. I digitize these maps, associating each power plant with a specific location. I supplement this data with information on the timing of plant openings to construct a decennial panel of power plants from 1930 to 1960.

There was substantial development of new power plants throughout this period. Between 1930 and 1960, over 1600 new power plants were built. Figures 9-12 display the geographic pattern of power plant construction. These figures present the location of each power plant by capacity.[40] In 1930, there were already substantial development of plants throughout the northeastern US and in California. Meanwhile, very few plants had been built throughout much of the midwest and southern US. Over the next 30 years, there was a dramatic increase in both the number power plants and the average capacity of each plant. New plants continued to be built along the west coast and throughout the northeast. There was also a striking expansion of new facilities throughout the south and midwest. By 1960, there wide coverage of power plants throughout the country.

[40]The maps exclude plants with less than 10mw of capacity, for reasons that will be discussed later in this section.

The identification strategy is based on plausibly exogenous variation in the cost of providing electricity to different communities. In particular, I exploit the fact that power companies were more likely to supply electricity to communities that were located near a power plant. I estimate instrumental variables (IV) regressions, using county-distance to the nearest power plant as an instrument for household electrification and appliance ownership. The main instrument, $distance_{it}$, is the distance (in miles) to the nearest power plant for county i in year t.[41] This variable is created by combining information on the location of new power plant openings with the coordinates of each county centroid.

Two assumptions must hold for this identification strategy to be valid. First, county-distance to power plants must be a strong predictor of the proportion of homes with electricity and modern appliances. This assumption is supported by historical evidence and is borne out in the data.[42] Power companies were responsible for the construction and maintenance of transmission lines (Hughes, 1993). Power line construction was a significant financial cost to companies,[43] and played an important role in determining which households received electricity (Lovell, 1941). In addition, because of technological limitation on maximum line voltage, transmission loss was a major concern for power companies.[44] Since transmission loss is directly proportional to transmission distance, power companies had an additional incentive to provide electricity to customers residing near power plants.

The second assumption is that changes in county-distance to power plants were uncorrelated unobservable determinants of fertility or child quality.[45] This assumption consists in both an independence restriction and an exclusion restriction. The independence restriction requires that, conditional on covariates, the decision about where to locate a power plant

[41]Specifically, this instrument is constructed based on hydroelectric and steam power plants with at least 10mw of capacity.

[42]Section 6.1 reports the first-stage relationship between county-distance to power plants and household electrification.

[43]Between 1930 and 1940, construction of new transmission lines accounted for roughly 15% of total capital expenditure for new construction in the industry (*Electrical World*, Jan. 13, 1940).

[44]In 1929, transmission loss accounted for 15% of total power production in the US (*Electrical World*, Jan. 13, 1930).

[45]Formally, this conditions requires that $\text{Cov}(\Delta distance_{it}, \Delta\epsilon_{it}) = 0$ and $\text{Cov}(\Delta distance_{it}, \Delta u_{it}) = 0$, where ϵ_{it} and u_{it} are the error terms from equations (5) and (6).

was made independently household characteristics. The exclusion restriction requires that proximity to power plants did not have direct effects on child outcomes.

To examine the independence restriction, I turn to historical evidence on how power plant sites were chosen. The two dominant sources of power generation throughout this period were hydroelectricity and steam, which accounted for over 98% of electricity generated in the US in 1960 (Federal Power Commission, 1962).[46] Both steam and hydroelectric plants had very long life-spans: steam plants ranged from 30 to 50 years, while hydroelectric plants ranged from 50 to 100 years (International Energy Agency, 2010). Thus, it is highly unlikely that the decision about where to build a plant would have been influenced by transitory shocks in the local demand for power.[47]

Companies also faced substantial constraints on where plants could be built. For hydroelectric plants, topographic characteristics played the dominant role in choice of site (Rushmore and Lof, 1923; Federal Power Commission, 1962). Potential capacity at a particular site depends on both the height of the dam and the rate of water flow. The suitability of a potential location also depends on the consistency of water flow during the year, while construction costs are closely related to the width of the river. Ideal sites for hydroelectric plants are locations with sufficient gradient, where the river has narrowed. The importance of these factors overwhelmed concerns about transmission costs (Lovell, 1941).

Cost considerations were also the dominant factor in the site selection for steam power plants. Steam plants used large amounts of coal, which required them to to locate near a rail lines or coal mines.[48] Freight costs created an added incentive to locate plants near direct sources of coal.[49] Steam plants also needed to locate near an appropriate water supply. For

[46] I exclude internal combustion (IC) power plants from the analysis. IC plants, fuelled by oil, were much smaller than steam or hydroelectric plants, and were often used as auxiliary power during peak load periods, or for small loads. Because power companies faced few constraints in where IC power plants could be built, their location was potentially influenced by household characteristics, a violation of the independence restriction.

[47] Since all regressions control for county fixed effects, decisions about where to build a power plant need only be uncorrelated with time-varying local characteristics.

[48] Coal accounted for more than 70% of plant operating costs, and in 1930, an average sized steam plant would burn roughly 30 tons of coal per hour (Lovell, 1941).

[49] On average, freight costs comprised two-thirds of the total cost of shipped coal, where the freight rate

every pound of coal, a steam plant required 400 pounds of cooling water (Leclair, 1933). The water temperature also played a crucial role in the performance of the steam turbine, and slight differences in the source water temperature had large effects on coal requirements. Given the critical importance of these cost factors, companies adopted a two-stage approach to plant construction and distribution: first, they determined where to situate a plant on the basis of these cost factors, then they chose where to build transmission lines (Lovell, 1941).

The identification strategy also requires that the exclusion restrictions hold. Proximity to power plants can only have influenced child outcomes through changes in household technology. There are two main threats to the exclusion restrictions. First, electrification may have had effects on local economic activity, which in turn could have influenced either fertility or child investment decisions. Since industry electrification preceded household electrification by several decades (Gray, 2012) it is unlikely that the construction of new plants had much effect on local business. Still, I address this concern by directly examining the relationship between power plant construction and employment and industry composition. Second, local electrification may have had direct effects on children through improvements in local schools or better local health care. Again, I address these concerns by directly examining the relationship between local access to power and quality of education and health care. The results suggest that the primary impact of local electrification occurred within the households, supporting the exclusion restrictions.

5 Data

5.1 County-level data

The baseline empirical analysis relies on a county-level panel for the years 1940 to 1960, which results in roughly 3,000 county-level observations per decade. County-level information about appliance ownership and electrical services are available from the census. For each county, the

per ton was equalt to $\$.90 + \$0.0035\times$ miles haul (Fowle, *Electric World*, Mar 12, 1938).

level of household technology is proxied by the proportion of households with refrigerators, modern stoves (fuelled by electricity or gas as opposed to coal, wood, or kerosene), or electric lights. The census did not report these variables in every year. The number of households with electric lights and refrigerators are reported in 1940 and 1950; information on cooking fuel (used to construct the measure of modern stoves) is available in 1940, 1950, and 1960. These data are supplemented by a rich set of county-level information on economic and demographic variables (Haines, 2004).

The county-level fertility rate is calculated as the number of infants per 1,000 women aged 15 to 44. Child quality is proxied by the proportion of children attending school (aged 5-6, 7-13,14-17), and the infant mortality rate (calculated as the number of infant deaths per 10,000 live births). Finally, I combine information on county-centroid with data on the construction of new power plants to create the county-level instrument, $distance_{it}$.

There were large cross-county differences in the diffusion of modern appliances and electricity. Figure 13 to 15 report the change in proportion of households with electric lights, modern stoves, and refrigerators for the period 1940 and 1960. Between 1940 and 1950, there was little change in the proportion of homes with electric lights in western or northeastern states, since most homes already had electricity by 1940. Meanwhile, there was substantial electrification throughout the midwestern and southern states. The diffusion of modern stoves followed a similar pattern between 1940 and 1960, with the largest adoption occurring in the midwest and southern US. The diffusion of refrigerators lagged in the south, and was more widespread in the north and northeastern part of the country. Since refrigerators were more expensive than other appliances, financial constraints may have played a role in the lagged adoption in the south.

Figure 16 reports the change in county-distance to power plants for the period 1940 to 1960. This figure is constructed using information on new power plant openings and county centroid location. The largest changes in county distances to power plants occurred throughout the midwestern and southern US, consistent with the pattern of power plant diffusion observed in Figures 8 to 11. Since there was already significant development of power plants in the northeast and western US, there was little change in average county-distance to power plants throughout these regions. Comparing Figures 13 to 15 to Figure 16, the pattern of diffusion of electricity and modern appliances was clearly related to the construction of new power plants, suggesting that proximity to power plants may serve as a valid instrument for the level of household modernization.

5.2 State-level data

I supplement the county-level regressions with a cross-state analysis. This approach offers several advantages. First, the Edison Electric Institute's *Statistical Bulletin* (EEI) provides state-level data on the proportion of households with electrical services, which allows me to extend to time period of study, and construct a decennial panel for the years 1930 to 1960. Second, I am able to combine this data with information on state and year of birth to examine the long-run effects of early access to modern household technology. Finally, there is more detailed information on infant mortality at the state-level, such as information on infant mortality by urban/rural status and information on neonatal mortality (infant mortality within 28 days of birth).

I use the EEI data to construct the state-level proportion of homes with electric lights for each decade from 1930 to 1960. I supplement this data with a variety of state-level covariates. The key dependent variables are the infant mortality rate, and rural infant mortality rate. To construct the state-level instrument, I aggregate information on county-level distance to power plants. In particular, I construct the state-level instrument as follows: $statedistance_{st} = \sum_{i \in s} distance_{it} \cdot popfrac_{is}^{1930}$. This variable is the population-weighted average distance to power plants for each state. The term $popfrac_{is}^{1930}$ is the fraction of the state population that resided in county i in 1930. Notice that time-variation in this instrument stems solely from changes in the term $distance_{it}$ and not from potentially endogenous changes in population.

Figure 17 displays the geographic pattern of diffusion of electric lights between 1930 and 1960 at the state-level. This pattern is similar to the diffusion observed at the county-level. Throughout this period, there was substantial electrification of the southern and midwestern states, and less change in the northeast or the west. In Figure 18, I report the changes in the state-level instrument $statedistance_{st}$ between 1930 and 1960. The largest declines in average state-distance occurred in the midwest, followed by the south. There is also a clear relationship between changes in the state-level instrument and the diffusion of electricity into the home.

5.3 State Economic Area (SEA) data

Finally, I use data available from Integrated Public Use Microdata Series (IPUMS) for the years 1930, 1940, and 1950.[50] This series provides micro-level data for individuals and households, where geographic information is available at the State Economic Area (SEA)-level. On average, there were roughly 6 counties per SEA. I combine this data with county-level counts for ownership of modern appliances electric lights to create SEA-level measures of the diffusion of modern household technology. I also construct an SEA-level instrument for access to electricity using a population weighted average distance to power plants for counties within each SEA, according to the procedure used to construct the state-level instrument.

An advantage of the microdata is that it allows for a more detailed examination of how different families were affected by the diffusion of modern household technology. For example, I can examine the impact of modern appliances on the fertility rates of women of different age groups, rather than simply estimating the overall effect on fertility.

The data allow me to study other effects of household modernization. I examine whether household modernization had effects on male and female employment and employment by occupation. I use information on the location of family members to construct an indicator for whether an adult child co-resides with a parent. This variable allows me to examine whether

[50] Geographic information is not available at the sub-state level in 1960.

household technology had effects on family living situations. Finally, I use retrospective information on place of residence to examine whether electrification had effects on migration patterns. In particular, I construct a dummy variable which is equal to one if an individual reported having moved from a different SEA during the past year (in 1950) or past five years (in 1940).

6 Results

6.1 First-stage results

Before reporting the main results, I first confirm that distance to power plants has strong predictive power for household electrification and modern appliance ownership. Table 4 reports the first-stage results at the county-level. Each cell corresponds to an estimate from a different regression. Across a variety of specifications, there is a strong relationship between distance to power plants and the proportion of homes with electric lights and modern stoves. The lack of a first-stage relationship for refrigerator ownership may reflect the important role cost factors in purchasing decisions. In the preferred specification, a 1 standard deviation (40 mile) decrease in county-distance to a power plant was a associated with roughly a 2 percentage point increase in electrification rates and stove ownership. These estimates are highly significant.[51] In alternative specifications, I run the first-stage regression using a vector of distance dummies (see Appendix A). The construction of a power plant within 40 miles of a county would be expected to raise electrification rates by 5 percentage points relative to a county at least 60 miles from a power plant.

Tables 5 and 6 report the first-stage estimates using the state- and SEA-level data. Again, there is a consistent relationship between average distance to power plants and the level of household technology. The point estimates are negative and statistically significant.[52] In the

[51]For electric lights, the F-statistics range from 19 to 52; for modern stoves, the F-statistics range from 14 to 91.

[52]Although the estimates much smaller for ownership of refrigerators in Table 7.

preferred specifications, a 1 standard deviation decrease in average distance to power plants was associated with roughly a 4 percentage point increase in household electrification rates.

6.2 Household technology and fertility

The model is ambiguous as to the effects of households technology on fertility (see equation (iii) from Proposition 1). On the one hand, the time-savings associated with modern appliances should generate increases in fertility. On the other hand, the health improvements associated with modern household technology should lead families to have fewer children of higher quality. To shed light on this question, I estimate the reduced form relationship between household technology and fertility given by equation (5).

Table 7 reports the estimates for fertility - defined as the number of births per 1,000 women aged 18 to 44. The first three columns report the least-squares estimates. There is no evidence that household technology was associated with increases in fertility. The point estimates are all negative an statistically significant. In column 3, a 1 standard deviation increase in household electrification is associated with 4.7 percent decline in fertility. Columns 4 to 6 report the results from the IV regressions. Again, there is no evidence that improvements in household technology led to increases in fertility. The point estimates are all close to zero and statistically insignificant. The results confirm the findings of Bailey and Collins (2009) that the diffusion of modern appliances into the home was unlikely to have caused the baby boom. The IV results further suggest that the time-savings and direct health effects of household modernization roughly offset each other in terms of their effects on fertility.

Table 8 reports the estimated effects of household electrification on fertility for women aged 18-34 and 35-49 based on SEA-level microdata. Fertility is constructed based on whether or not she has a child under age 5. The OLS estimates are negative for both groups, although the point estimates are twice as large among older women. Similarly, the IV estimates are small and insignificant for women aged 18-34, but negative and significant for women aged 35-49.

One explanation for the timing of the effects on fertility is that access to household technology did not affect child-spacing but did affect desired completed fertility. Alternatively, this result may be due to differences in the time-savings associated with household modernization. During this period, mothers relied heavily on older siblings to help care for young children (Schwartz Cowan, 1983). As a result, young mothers differentially benefited from the time-savings associated with modern household technology, since they did not have had older children to assist with child-care duties. Because time-savings should lead to *increases* in fertility, we would expect to observe relatively smaller declines in fertility among younger women (who benefited more from the time-savings associated with household electrification).[53]

6.3 Household technology and child quality

Equation (ii) in Proposition 1 reveals that improvements in household technology should unambiguously improve child quality. Labour-saving appliances reduced the time-cost of child investment, which should lead parents to increase investment in children. Meanwhile, modern household technology directly benefited child health, which should lead to additional increases in child quality. I investigate these predictions empirically, using information on school attendance and infant mortality as proxies for child quality.

6.3.1 School attendance

Table 9 reports the estimates for the effect of electrification on school attendance of cohorts aged 5-6, 7-13, and 14-17. Row 1 reports the estimates for children aged 5-6. Household electrification had a large impact on school attendance: the OLS estimates imply a 1 s.d. increase in the proportion of homes with electricity would raise school attendance by 5 per-

[53] Formally, consider the estimates for two different cohorts of mothers: β_1^{Young} and β_1^{Old}. Assume that both types of homes benefited equally from the health effects of modern technology, $\theta'(\bar{z})^{Young} = \theta'(\bar{z})^{Old}$, but that young mothers benefited more from the time-savings of modernization, that is $\tau_Q'(\bar{z})^{Young} < \tau_Q'(\bar{z})^{Old}$, we have that $\beta_1^{Young} - \beta_1^{Old} = \frac{\partial \bar{n}}{\partial \tau_Q(z)} \cdot \left[\tau_Q'(\bar{z})^{Young} - \tau_Q'(\bar{z})^{Old}\right] > 0$.

centage points, while the IV estimates imply that a 1 s.d. increase household electrification would have raised early school attendance by 8 to 13 percentage points.

The second row reports the estimates for children aged 7 to 13. There is no evidence of a positive relationship between household technology and school attendance in either the OLS or IV regressions. In the preferred specification, we can rule out that a 1 s.d. increase in household would have generated more than a 1.5 percentage point increase in school attendance. This null finding is likely due to the fact that school attendance was virtually universal for this cohort, so there was little scope for improvements in household technology to have affected school attendance.

The third row reports the estimates for children aged 14 to 17. There is some evidence that household electrification led to increases in high school attendance. The least squares estimates imply a 1 s.d. increase in household electricity was associated with a 1 to 2 percentage point increase in school attendance, however, the IV results are less consistent, and generally insignificant.

I examine whether improvements in household technology had differential effects on school attendance by gender. I estimate the effect of household electrification on the gender-gap in school attendance. The dependent variable is constructed as the difference in school attendance (boys minus girls) for age cohorts 5-6, 7-13, and 14-17.

These results are reported in Table 10. Among younger children, there is no evidence that household technology had different effects by gender. For both the 5-6 and 7-13 age cohorts, the point estimates are consistently small and insignificant. For high school aged children, there is some evidence that household modernization differentially raised school attendance among girls. In the IV regression, the point estimates are all negative and statistically significant, ranging from -0.004 to -0.009.

There are two main reasons why high school girls may have differentially benefited from improvements in household technology. First, daughters were far more likely to share the burden of domestic work. In 1930, high school girls spent almost 20 hours per week on home production, whereas high school boys spent less than 5 (Ramey, 2009). As families acquired labour-saving appliances, the opportunity cost of sending a high school aged daughter to school was lowered. Second, as the time-costs of home production were reduced, young women may have anticipated that they would be more likely to enter the labour market in the future. In anticipation of future employment, these may have chosen to invest more in their own education.[54]

6.3.2 Infant mortality

Table 11 reports the county-level estimates for infant mortality. These models are estimated for decennial years from 1940 to 1960.[55] The first three columns report the least-squares estimates. The point estimates are all negative, although statistically insignificant in the fully specified model. Columns (4) to (6) report the IV estimates. These estimates are all negative and statistically significant. In the fully specified model, a 1 s.d. increase in household electrification was associated with a decline of 18 infant deaths per 10,000 live births, roughly a 5 percent decline in the infant mortality rate.

Table 12 reports the corresponding estimates from state-level regressions. These models allow me to extend the analysis for the period 1930 to 1960. In addition, I include state-level controls for the maternal mortality rate - a variable that is meant to capture the overall quality of medical care during childbirth. The dependent variable in these regressions is the white infant mortality rate (per 10,000 live births).[56] The least squares estimates range from -1.5 to -3.2, and IV estimates range from -4.0 to -5.1.[57]

These estimates are large. Given the diffusion of household electricity between 1930 and 1960, out-of-sample calculations suggest that the diffusion of electricity into the home

[54]Since virtually all prime-aged males already worked, there would have been no scope for improvements in household technology to have influenced their future labour force decisions. Similarly, Albanesi and Olivetti (2011) that reduction in maternal mortality rates raised expected future earnings for young women and caused them to acquire more education.

[55]To avoid small-sample issues, I restrict the sample to counties with at least 500 live births in 1940, the results are not sensitive to this cutoff.

[56]Regressions using total infant mortality rates yield very similar estimates.

[57]Figure 22 reports the residual plot from the OLS regression.

can explain between 25% and 35% of the total decline in infant mortality throughout this period. The size of these effects corresponds with previous research on the importance of household sanitation for infant health. Watson (2005) finds that federal interventions to improve household sanitation on Native reserves by providing homes with running water and indoor plumbing can explain 40% of the decline in the Indian-White infant mortality gap since 1970. Household electrification offered a variety of health benefits in addition to pumped water for many rural homes, so it is not surprising that it had such a dramatic effects on infant mortality.

The impact of electrification on rural infant mortality is reported in the lower portion of Table 12. The OLS estimates are similar in magnitude to the estimates for overall infant mortality. The IV estimates are all large and statistically significant. In fact, the estimates for rural infant mortality are roughly 35% larger than those found for overall infant mortality.

The fact that the declines in infant mortality were larger in rural areas provides confidence in the empirical strategy. Medical improvements and water infrastructure investments had disproportionate effects on infant mortality in urban areas (Jayachandran et al., 2010; Cutler and Miller, 2005). If household electrification were correlated with either of these interventions, we would expect to estimate larger declines in urban infant mortality. In addition, power companies had little interest in supplying electricity to rural homes (Tobey, 1996, pp.14), so it is highly unlikely that decisions about where construct power plants were influenced by the characteristics of rural households. Thus, these results provide additional support for the exogeneity of the instrument.

The fact that household electrification had a larger impact on rural infant mortality is consistent with historical evidence that rural areas disproportionately benefited from electrification. While the majority of urban homes had indoor plumbing by 1930, in rural areas electrification provided homes with access to pumped water (Strasser, 1982). Rural families disproportionately benefited from the time-savings associated with modern household technology, since they had less access to domestic help (Schwartz Cowan, 1983).

7 Robustness checks

7.1 Alternative specifications and controls

In Table 13, I examine the robustness of estimates effects for infant mortality. For reference, column (1) reports the baseline estimates. Column (2) includes a linear state trend. In all four regressions, the point estimates are significant, albeit slightly smaller than the baseline estimates. The findings indicate that differential trends in infant mortality across states cannot be driving the main results.

The main estimates could have been caused by convergence in infant mortality. States with low levels of electrification in 1930 may have experienced relative declines in infant mortality for reasons unrelated to improvements in household technology. If so, the main results would overestimate the impact of household electrification on infant mortality. This concern is addressed in the baseline model with the inclusion of a flexible region-year interaction term. As a result, only within-region convergence in infant mortality could bias the main estimates. I further explore this issue in columns (3) and (4). In column (3) I report the estimates from models that control for the lag of infant mortality. The point estimate are all significant, although smaller in magnitude that the baseline results.[58] In column (4), I report estimates from regressions that allow for differential trends according to baseline infant mortality rates. In particular, I construct a series of dummy variables for each quartile of infant mortality rates in 1930, and interact these dummy variables with a full vector of year fixed effects. These regressions control flexibly for differential trends across states with different baseline infant mortality rates, so convergence in infant mortality cannot bias the results. The point estimates in column (4) are all negative and generally significant. The results are somewhat smaller than those found in the baseline model, but still confirm that the baseline findings were not driven by convergence in infant mortality.

[58]The differences in magnitude between columns (1) and (3) are primarily due to the fact that controlling for the lagged dependent variable reduces the sample period to 1940-1960. The estimates in column (3) are very similar to results found from the baseline model when the year 1930 is omitted from the sample.

In column (5) I re-estimate the baseline model with an additional control for the proportion of births attended by midwives (as opposed to births attended by a physician or in a hospital). This variable is meant to capture the quality of medical care during childbirth. In principle, the choice of birth attendant was potentially influenced by the state of household technology, which is why this covariate was excluded from the baseline model. In practice, the inclusion of this covariate has almost no effect on the estimates.

Column (6) includes controls for state-spending on maternal education. Between 1922 and 1929, the Sheppard-Towner Act provided matching federal and state grants for maternal education programs.[59] The control variable is constructed as an interaction between state Sheppard-Towner funding (high versus low) and a vector of year fixed effects. Intuitively, this specification allows states that spent large amounts of money on maternal education in the 1920s to have experienced differential changes in infant mortality between 1930 and 1960. Including this variable in the regressions has little effect on size or significance of the main point estimates.

Finally, in column (7) I exclude northeastern states and California from the analysis.[60] Electricity had diffused widely throughout these regions by 1930, so we would not expect the main estimates to have been driven by these states. Excluding these regions from the analysis slightly increases the magnitude of the point estimates.

7.2 Testing the exclusion restriction

The identification strategy for the IV regressions requires than an exclusion restriction hold. Changes in proximity to power plants cannot have had direct effects on child outcomes. The instrument can only have operated through changes in the level of household technology. To examine this question, I estimate the reduced form relationship between local electrification and potentially relevant outcomes.

[59] See Section 8.2 for a more thorough discussion of the act.

[60] The excluded states are California, Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

7.2.1 The effect of electrification on migration

First, I investigate whether local electrification had direct effects on the demographic composition of communities through migration. Specifically, I investigate whether individuals were more likely to migrate towards regions that were electrified and away from non-electrified areas. Even if local electrification had effects on net migration the baseline results will not necessarily be biased, since all regression models controls for the size of the local population. The concern is that electrification had differential effects on mobility according to individual characteristics. For example, if health-conscious families were more likely to migrate towards electrified towns, the baseline regressions might over-estimate the causal effect of household electricity on infant health. If electrification led to this form of non-random migration, the baseline model would confound the treatment effect with changes in the composition of the local community.

To examine whether electrification was associated with non-random migration, I use individual-level data from the IPUMS for the year 1940 and 1950. The dependent variable is a dummy variable which is equal to one if an individual reported having moved from a different SEA during the past year (in 1950) or past five years (in 1940). I estimate the models for the full sample, and separately for high- and low-educated individuals.

Table 14 reports these estimates. The top row reports the results for the full sample. In the least-squares regressions, there is some evidence that electrification was associated with net migration inflows, although the point estimates from the IV regression are somewhat smaller and statistically insignificant. The bottom two rows report the estimates separately for high educated ($\geq$ high school) and low educated ($<$ high school) individuals. There were significant differences in how these two groups responded to electrification. Less educated individuals were far more likely to migrate towards (away) from high (low) electrified communities. The point estimates imply that a 1 s.d. increase in electrification rates would generate a 5 percentage point increase in the probability of migration.

The patterns found in Table 14 suggest that local electrification did have modest effects mobility. However, it is unlikely that changes in the composition of local communities caused by migration drove the main results. Since less educated individuals were more likely to migrate towards electrified communities, if anything, the baseline results may understate the true causal effect of household technology on child health.

7.2.2 The effect of electrification on employment

I examine whether electrification had effects on the local economic environment. Improved labour market opportunities could have affected child outcomes independent of technological changes that occurred within the home. To investigate this issue empirically, I examine whether changes in electrification had effects on male employment.[61] I use individual-level data from the IPUMS to estimate the effect of electrification on the employment status for men of different age groups.

Table 15 reports the results. In both the OLS and IV regressions, the point estimates are all very small, and generally insignificant. Most point estimates are negative, and we can rule out that a 1 s.d. increase in local electrification would have generated more than a 2 percentage point increase in male employment. These findings confirm that improvements in child health and education outcomes were unlikely to have been the result of better labour market conditions. There is no question that electricity had dramatic effects on industry in the early 20th century, however, the vast majority of businesses already had electricity by 1930 (Jovanovic and Rousseau, 2005; Gray, 2011), so there was limited scope for electrification to have had direct effects on labour market outcomes after 1930.

7.2.3 The effect of electrification on hospital quality and neonatal mortality

Finally, I examine whether electrification had effects on the quality of hospital care. If local access to electricity led to improvements in the quality of hospitals, we would expect electrification to have been associated with declines in home-delivered births. In addition,

[61]Future work will investigate whether electrification had effects on local industry composition.

better hospitals should have led to declines in neonatal mortality, since survival depends critically on medical care immediately after birth (Paneth, 1995; Williams and Chen, 1982).[62] Because household technology could at most have indirect effects on neonatal mortality (potentially by reducing incidence of low birth-weight births), this analysis also provides a useful placebo test.

The top half of Table 16 reports the estimates for the proportion of births attended by a midwife (as opposed to a doctor or at a hospital). There is strong evidence that electrification reduced the use of midwifes during childbirth. The point estimates are all negative and generally significant. The bottom half of Table 16 reports the estimates for neonatal mortality. Although the OLS estimates are marginally significant, the IV regressions confirm that electrification had no impact on neonatal mortality rates. The preferred estimates are small and highly insignificant. Together the results in Table 16 suggest that electrification influenced the choice of *where* mothers gave birth, but had no effect on neonatal health.

The fact that there was no relationship between electrification and neonatal mortality suggests that local access to electricity did not lead improvements in the quality of hospital care. These results provide additional evidence that the main channel through which electricity affected infant health was through improvements in the level of household technology. It may seem surprising that electrification influenced the choice of *where* mothers gave birth, given that it did not affect the quality of hospitals. However, an increase in the use of formal medical care could reflect the fact that improvements in household technology led to greater parental investments in health.

[62] The leading cause of neonatal mortality throughout this period was premature birth. Before 1950, the main technology used to treat preterm infants was the incubator, which was first adopted in nurseries in 1922 (Cutler and Meara, 2000).

8 Comparing the direct health benefits and time-saving benefits of household electrification

Having verified that the exclusion restrictions hold, and that electrification primarily influenced child quality through changes within the household, I now examine *how* improvements in household technology affected child health. In particular, I study whether the large declines in infant mortality were due to increases in parental investments, or driven by direct health benefits associated with modern household technology.

8.1 Household electrification and exposure to indoor air pollution

To begin, I investigate the extent to which improvements in household technology directly affected infant health. In the analysis, I focus on exposure to indoor air pollution. Indoor air pollution from the use of solid cooking fuels is currently the second leading worldwide environmental cause of infant death, and was historically a major problem given the reliance on coal for cooking and heating. A key direct health benefit associated with modern household technology was the elimination of need to use coal and wood for cooking and heating.[63]

The analysis exploits regional heterogeneity in baseline exposure to indoor air pollution. In particular, I study the effect of household electrification on infant mortality in states that originally relied heavily on coal for cooking and heating. If modern household technology led to reductions in indoor air pollution, we would expect to observe larger declines in infant mortality in regions that were originally more reliant on coal for cooking and heating.[64]

[63]Improvements in household technology offered other direct benefits to infant health, for example, refrigerators led to declines in food spoilage and contamination. However, it is difficult to distinguish these effects from the health benefits associated with greater parental investment in child health.

[64]Formally, suppose that the direct health benefits were larger in states that were initially high users of coal, that is $\theta'(\bar{z})^{Highcoal} > \theta'(\bar{z})^{Overall}$. Comparing the estimated effects across these two population yields the following expression:

$$\gamma_1^{Highcoal} - \gamma_1^{Overall} = \left[\frac{\partial \bar{q}}{\partial \theta(z_i)} + \left(\frac{\partial \bar{q}}{\partial e} \cdot \frac{\partial \bar{e}}{\partial \theta(z_i)}\right)\right] \cdot \left(\theta'(\bar{z})^{Highcoal} - \theta'(\bar{z})^{Overall}\right) > 0.$$

Improvements in household technology should lead to larger increases in child quality in high coal regions. This result stems from both the direct health benefits of household technology, and because parents have an

I use information on the share of household using coal for heating in 1940 to rank states according to usage (Barreca, Clay, and Tarr 2012).[65] Figure 19 displays the state-level use of coal in 1940. States in the midwest and northeast were heavily reliant on coal, whereas there was far less use of coal in the southern and western US.

I restrict the sample to states in the top two quartiles of coal use in 1940, and re-estimate the baseline model for infant mortality and rural infant mortality. The estimates are reported in Table 17. For reference, the top rows reports the baseline results. Although restricting the sample size reduces precision, the point estimates in high coal-consuming regions are large and statistically significant.[66] The point estimates are generally between 25% and 50% larger in high coal consuming states. The preferred estimates imply that a 1 s.d. increase in household electrification would have saved an additional 41 infant lives (per 10,000 live births) in high coal consuming states. These findings suggest that reductions in indoor air pollution was a key channel through which modern household technology reduced infant mortality.

8.2 Household electrification and child investment

Improvements in household technology should have led to increased investments in child quality, due to both the time-savings and direct health benefits of modern household appliances. I examine whether increases in parental investments also played a role in the declines in infant mortality. The analysis relies on the idea that parents who were better informed about the importance of infant care and household hygiene practices would have been more likely to reallocate time to these activities.

The empirical analysis relies on cross-state differences in spending on maternal and infant care education. Between 1922 and 1929, the Sheppard-Towner Act provided matching grants

incentive to invest more in healthier children.

[65]This is the first year this data is available at the state-level. A ranking based on the proportion of household using coal-fire stoves in 1940 is very similar.

[66]The IV estimates in columns (5) and (6) are very large and imprecise. This stems from a weak instrument problem. In both cases the F-statistic on the instrument is less than 10.

to states for maternal education programs. This money was used to send out "prenatal letters" to pregnant women, provided class about infant care, and funded nurse visits into homes to provide information about better infant care practices (Moehling and Thomasson, 2012). I use total state spending between 1922 and 1929 under the Sheppard-Towner act to proxy maternal education in 1930.

There are several advantages to using the Sheppard-Towner Act as a proxy for baseline maternal education. First, the program was very effective in promoting awareness about better health practices accounting for 11% to 12% of the decline in infant mortality between 1922 and 1929 (Moehling and Thomasson, 2012). Second, the program immediately preceded the period in which modern appliances began diffusing into most homes, so the information would have been quite salient. Meanwhile, the Sheppard-Towner Act was repealed in 1929, so I can avoid confounding the direct effects of the program with the effects of household electrification. Third, there were substantial cross-state differences in spending on the program.

Figure 20 reports the fraction of total available Sheppard-Towner funds used by states between 1922 and 1929. There were no clear regional differences in terms of spending, although southern states were slightly more likely to spend money on the program. I restrict the sample to the top two quartiles of spending on the Sheppard-Towner Act and re-estimate the baseline models.

The results are reported in Table 18. In both the OLS and IV models, the point estimates are significantly larger than those found for the full sample. In the OLS regressions, the point estimates are roughly 35% larger for states that spend large amounts of money on maternal education. In the IV regressions, the point estimates are between 40% and 50% larger than for the full sample.[67]

Together, the estimates in Tables 17 and 18 provide some insight into how improvements in household technology affected infant mortality. Large declines in coal consuming states

[67] The magnitudes in the IV regressions should be interpreted with some caution, since the instrument is somewhat weak for the smaller sample.

suggests that modern household technology led to declines in exposure to indoor air pollution. Meanwhile, the fact that the declines in infant mortality were larger in states that had invested heavily in maternal education is consistent with modern household technology having led to increases in parental investments.

9 Other effects of household technology

To conclude the empirical analysis, I investigate whether improvements in household technology had other effects on families. I study whether the time-savings afforded by modern household appliances induced women to enter the labour force. I also examine whether household technology influenced decisions about whether or when to marry. Finally, I explore whether household technology had effects on the family living situation by investigating the relationship between the diffusion of modern appliances and the decline of 3-generational household.

9.1 Female employment

Table 19 reports the estimated effects of household electrification on female employment. Using SEA-level data for the years 1940 and 1950, I estimate the models separately for women aged 18-34 and 35-49. There is no evidence that improvements in household technology led to increases in employment among older cohorts of women. In fact, the point estimates from the IV regressions are all negative and moderately significant. For women aged 18-34, the OLS estimates are positive and moderately significant, however the IV estimates are all very small and statistically insignificant.[68] Across the range of estimates in Table 18, a 1 s.d. increase in household electrification would have led to at most a 1 percentage point increase in female employment.

These results suggest that the diffusion of modern appliances into the home had very

[68]Since the diffusion of electricity into the home may have been correlated with improvements in local economic conditions, it is not surprising that OLS estimates may be upward biased.

little effect on female employment in the US, which is consistent with historical evidence that labour-saving appliances did not cause women to reduce the amount of time spent on home production (Schwartz Cowan, 1983; Francis and Ramey, 2009). It should be noted that these estimates may not capture the full long-run impact on female employment if it took time to fully respond to improvements in household technology.[69]

9.2 Marriage decisions

I investigate whether improvements in household technology had effects on the decision to marry. By reducing the burden of housework, labour-saving appliances could have led to an increase in single-parent households (Greenwood et al., 2012). Household electrification could also have influenced the timing of marriage. For example, by reducing the demand for young women to work in domestic help.

The bottom half of Table 19 reports the estimated effects of household electrification on marriage for women aged 18-34 and 35-49. There is no evidence that household technology had any effects on entry into marriage. For women aged 18-34, we can rule out that a 1 s.d. increase in household electrification would have more than a 0.5 percentage point effect on marriage rates. One explanation for these results is that there continued to be strong social stigma associated with single parenthood.

9.3 Living situation

Finally, I study whether household technology influenced whether an elderly relative lived with an adult child. I restrict the sample to married women aged 25-34, 35-44, and 45-54, and construct a dummy variable for whether or not the respondent reported living in the

[69]For example, the first generation of women to have access to modern household technology may have underinvested in their own education since they had not anticipated the change in household technology. As a result, they may have been less likely to enter the labour market. Over time, younger cohorts of women could have made educational investments with full knowledge of the change in household technology, and these investments could have facilitated entry into the labour market. Future research will explore the long-term effects of household electrification.

same home as her mother.[70] These results are reported in the top half of Table 20. For older families, household technology had little effect on living situation. For women aged 25-34, household electrification was associated with a significant decline in the likelihood of living with a mother.[71]

The bottom portion of Table 20 reports the estimates for the probability of living with an adult child for women aged 50-59, 60-69, and 70-plus. Increases in household electrification was associated with declines in co-residence among women aged 60-69, but had no effect on the living situation of women over age 70. These results provide some evidence that improvements in household technology led to declines in 3-generational households. The effects were concentrated among younger families, which is consistent with labour-saving appliances having reduced the need for help raising young children. These results suggest that improvements in household technology may have played a role in the large declines in 3-generation household between 1900 and 1950.

10 Conclusion

This study investigates the impact of improvements in household technology on fertility, school attendance, and infant mortality for the period 1930 to 1960. I use a newly constructed dataset of the US power grid to identify the causal effect of access to electricity. The results suggest that modern household technologies caused families to make a quantity-quality tradeoff with children: electricity and modern appliances were associated with increases in early school attendance, decreases in infant mortality, and decreases in fertility.

The effects on infant health was large, and rough calculations suggest that the diffusion of electricity and modern appliances can explain between 25% and 35% of the total decline in infant mortality between 1930 and 1960. The empirical results also suggest that improvements in household technology had direct effects on infant health through reduced exposure

[70] The SEA-level data provides information on all family members living in the same residence.

[71] Similar regressions were estimated for the probability of living with an elderly father. Point estimates from these models were all statistically insignificant.

to indoor air pollution, and indirect effects on health through greater parental investments.

This study adds to our understanding of the 'household revolution' in the US. It provides insight into why, despite the substantial time-savings afforded by modern appliances, women did not reduce the time spent on home production. The results suggest that access to modern household technologies allowed families to increase home produced output, and that the main outcome of the 'household revolution' was healthier, better educated children.

This research also contributes to our understanding of the determinants of the dramatic declines in infant mortality during the first two-thirds of the 20th century. The results support previous work that has argued that preventative measures, such as improvements in household hygiene practices and infant care, played a role in improved health outcomes (Ewbank and Preston, 1989; Mokyr, 2000). In addition, the empirical results provide insight into the substantial declines in rural infant mortality that occurred throughout this period.

These results have implications for current policy. Despite new developments in off-grid electrification (UN Development Program, 2009; World Bank, 2010), over 1.6 billion people still do not have access to electricity (World Bank, 2008). This study indicates that there is large scope for such programs to improve child health and education.

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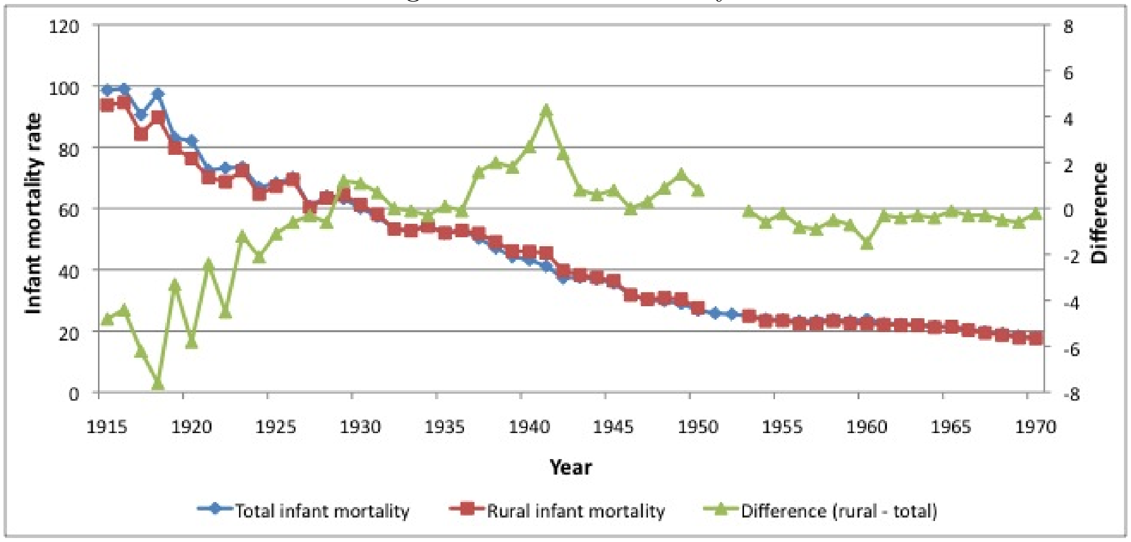
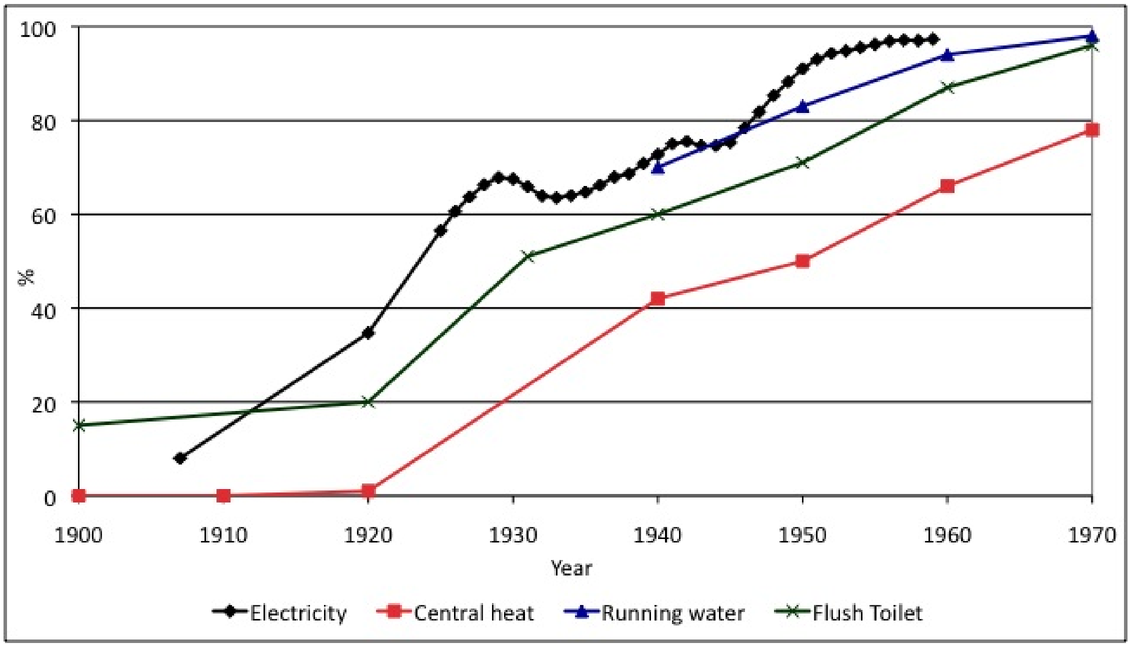
Figure 1: Infant mortality:

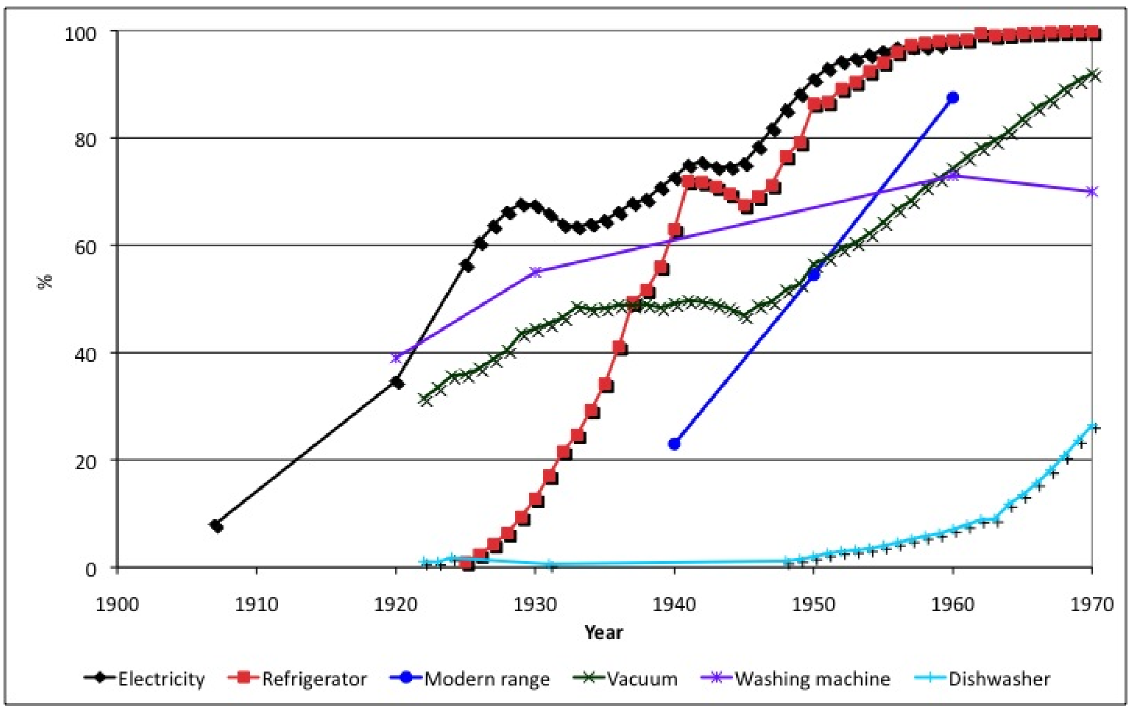


Source: Vital Statistics of the United States, 1900-1940, 1940-1960

Figure 2: Diffusion of modern technology



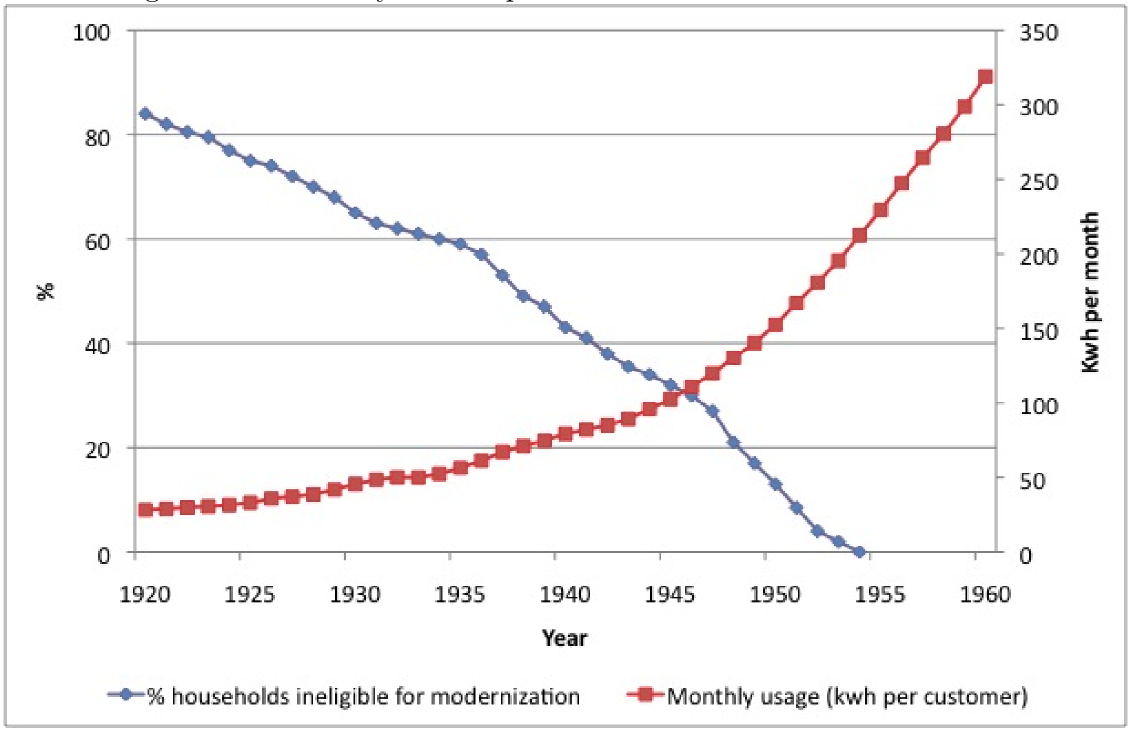
(a) Basic facilities



(b) Modern appliances

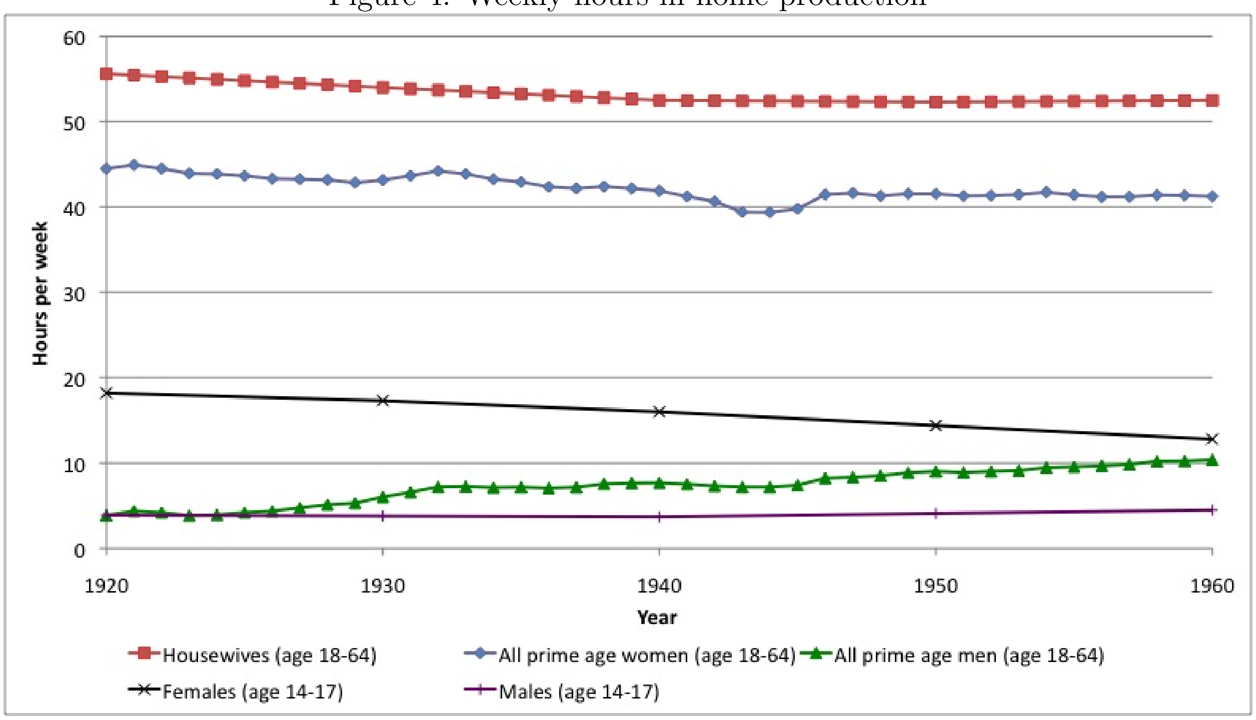
Source: Greenwood et al. (2005a), Bailey and Collins (2009).

Figure 3: Electricity consumption and modernization of the home



Source: Statistical History of the United States (1965), Tobey (1997).

Figure 4: Weekly hours in home production



Source: Ramey (2008).

Figure 5: Appliance advertisement

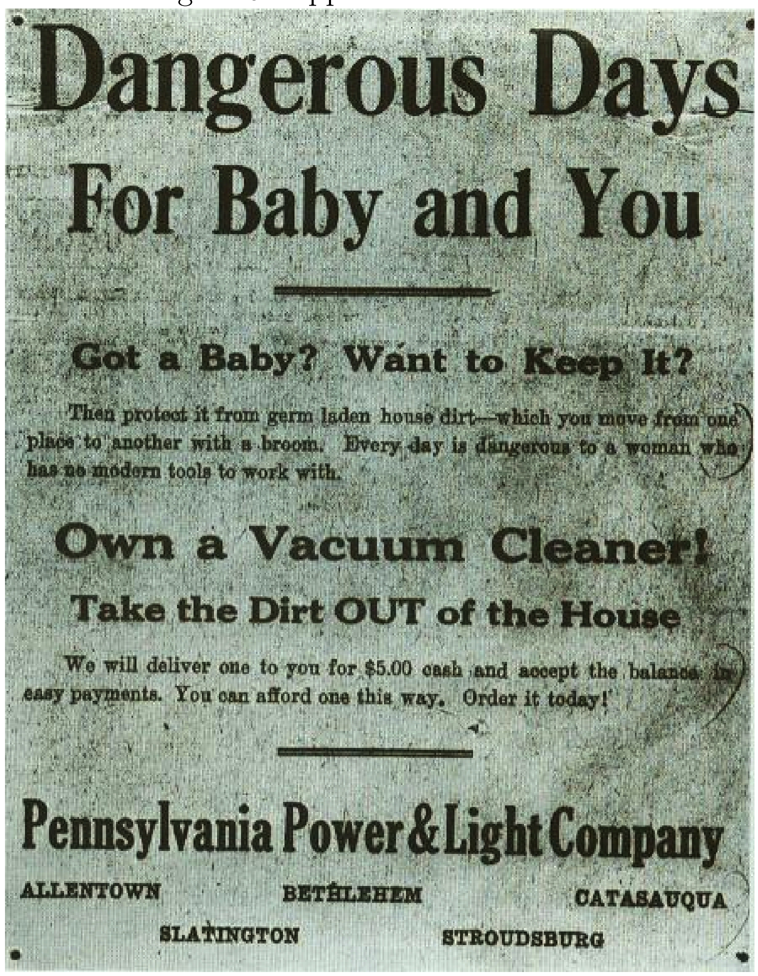


Figure 6: The effect of an increase in household technology on fertility (n) and child investment (e)

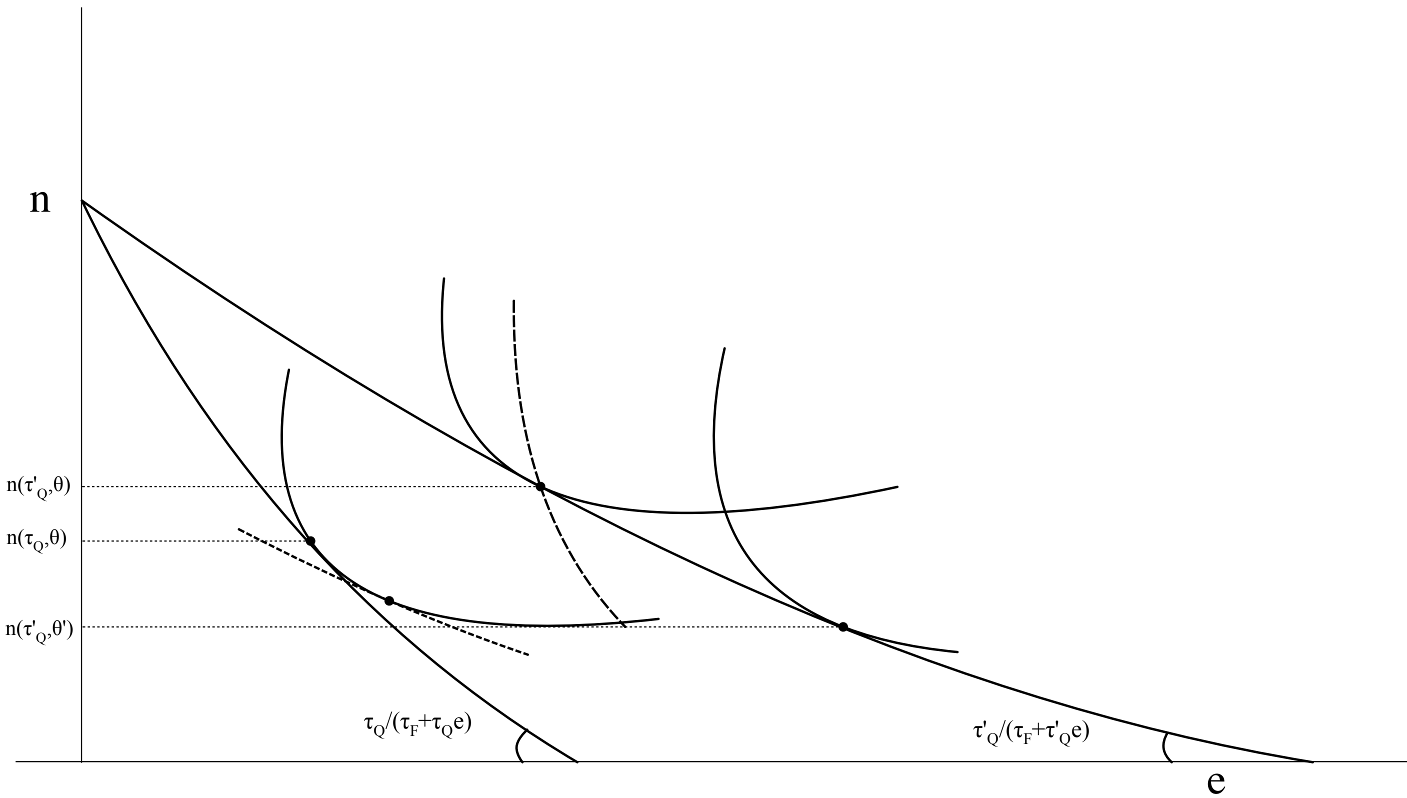


Figure 7: 1962 Federal Power Commission map of the U.S. power grid

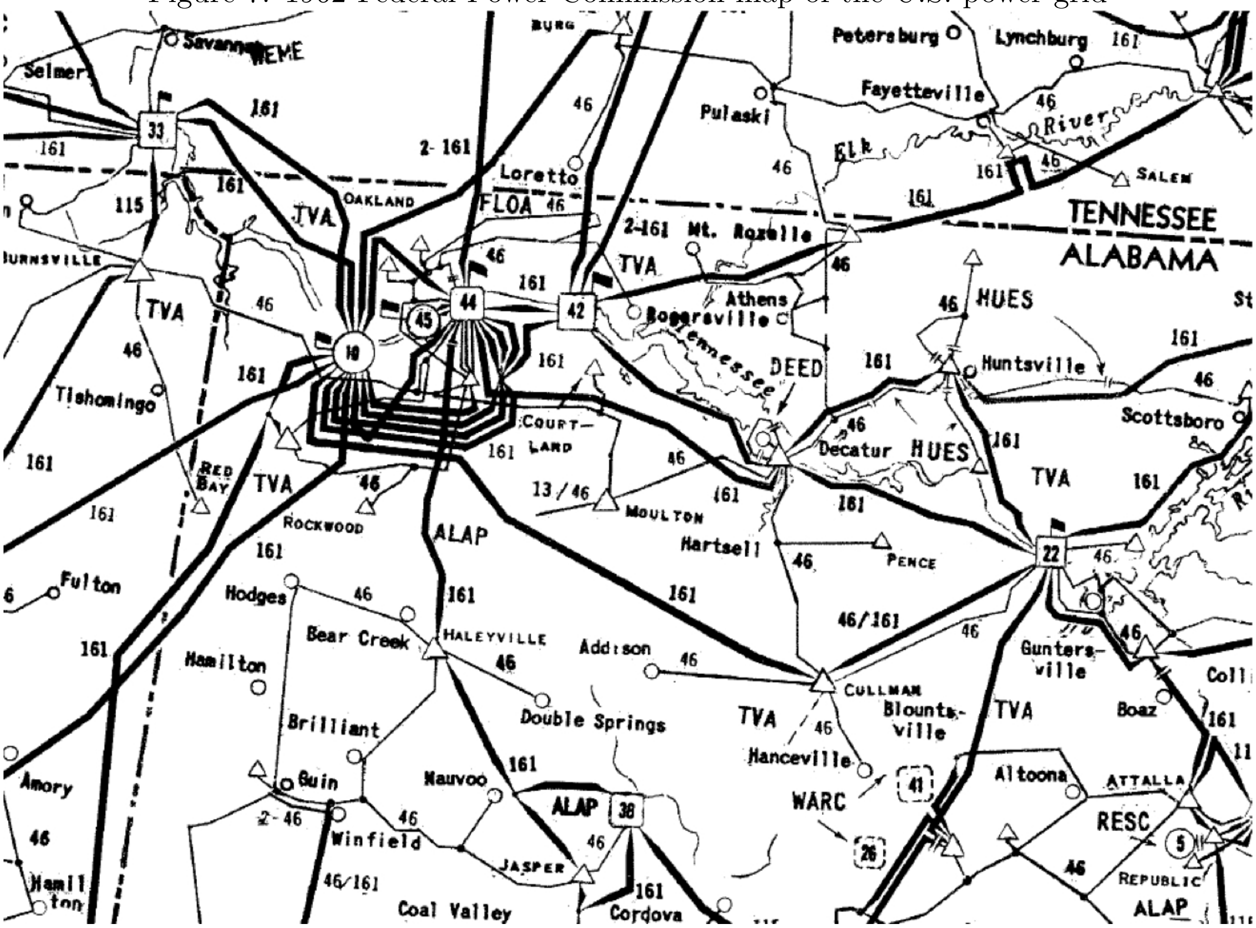


Figure 8: Power plant construction and county distance to plants

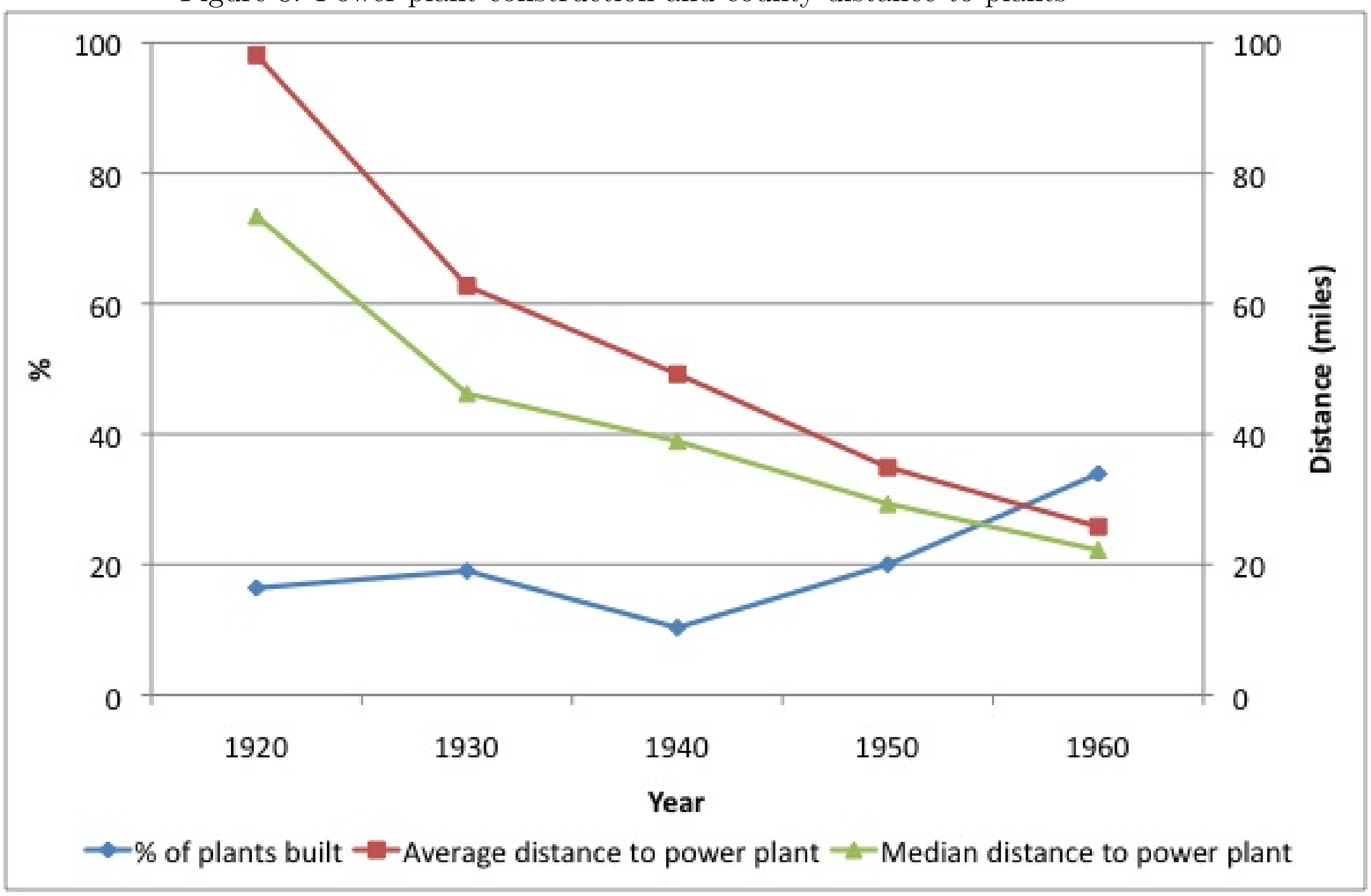


Figure 9: US power plants in 1930

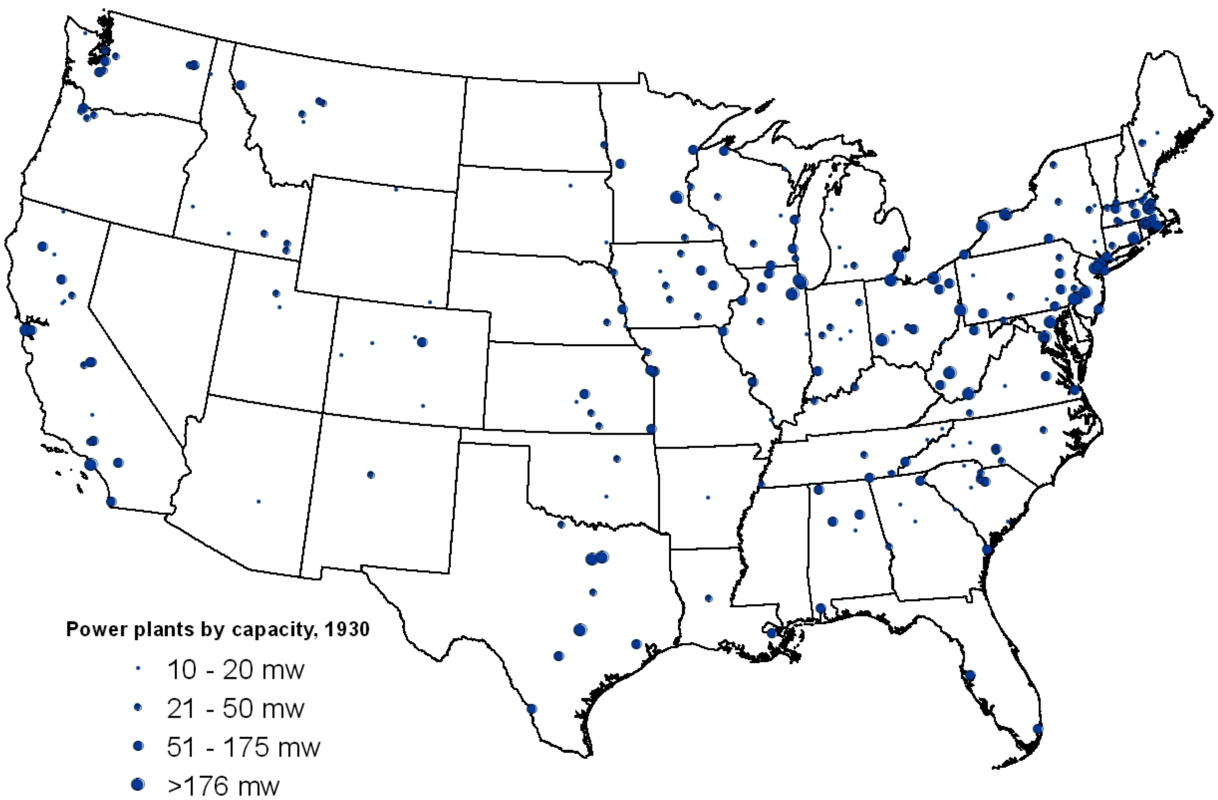


Figure 10: US power plants in 1940

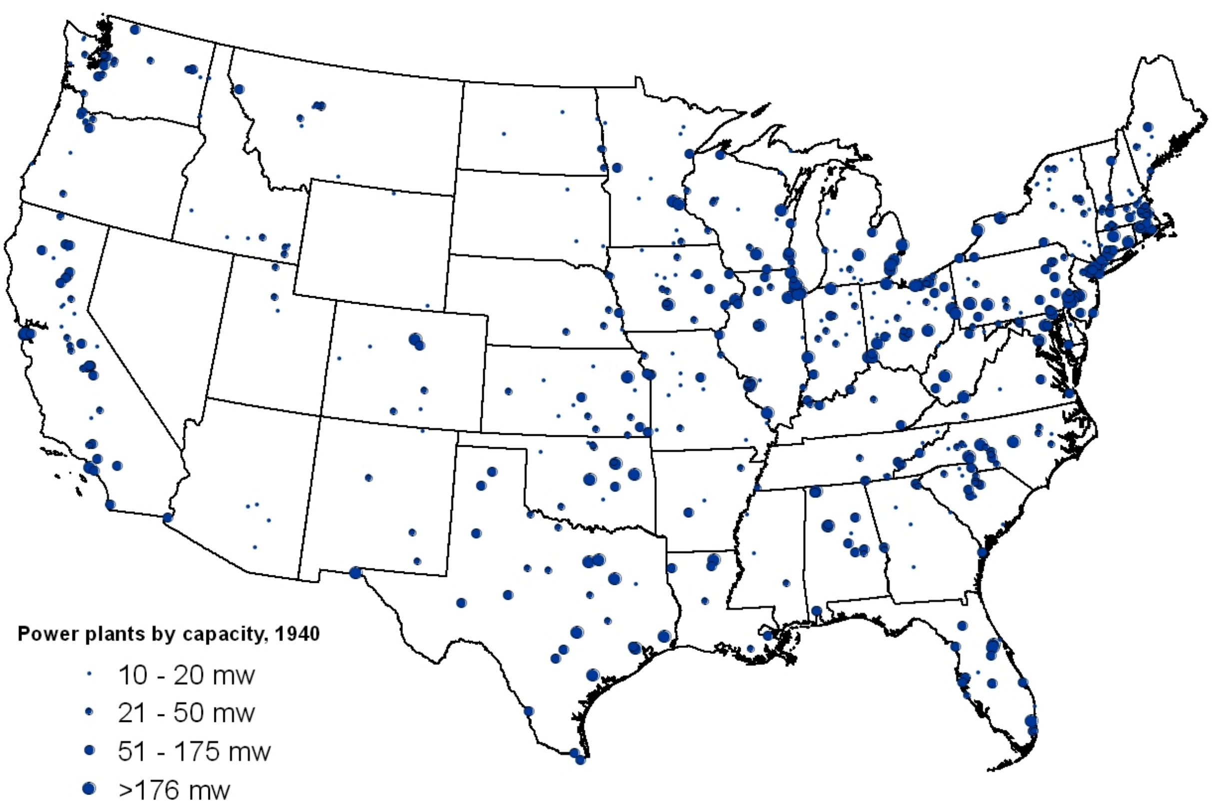


Figure 11: US power plants in 1950

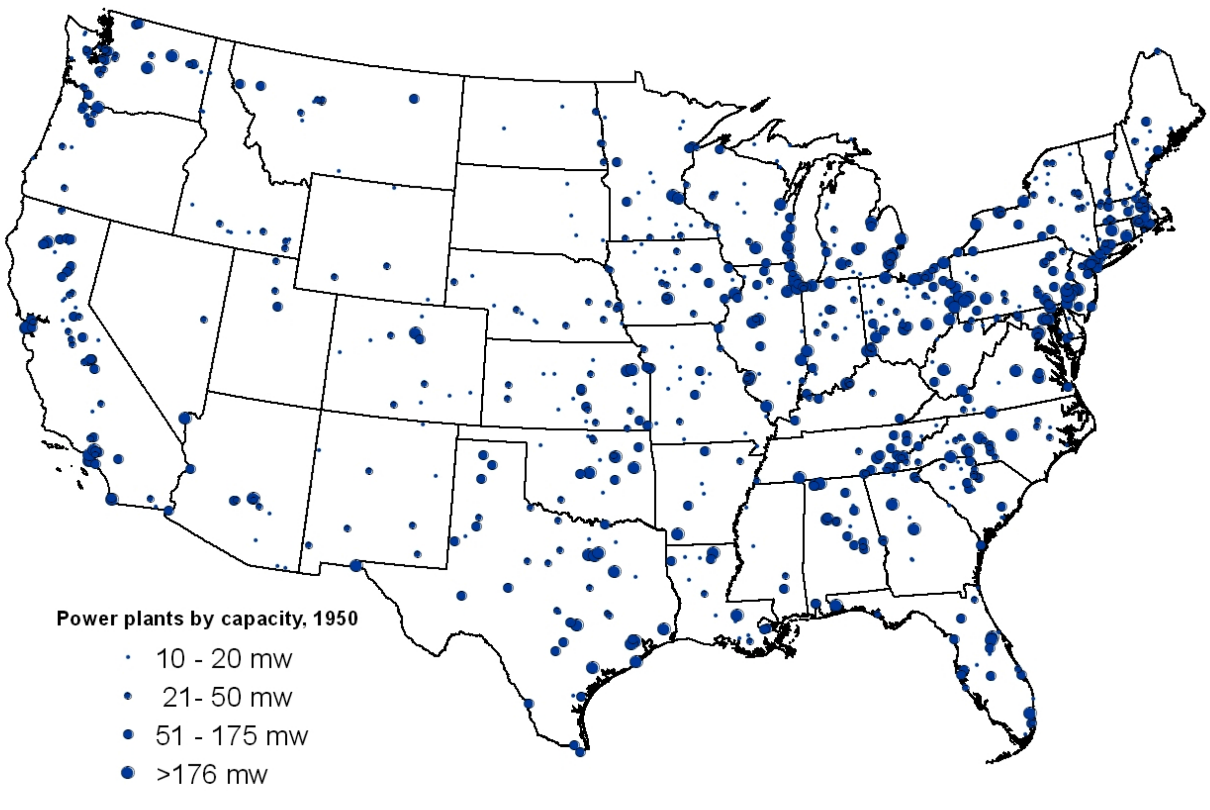


Figure 12: US power plants in 1960

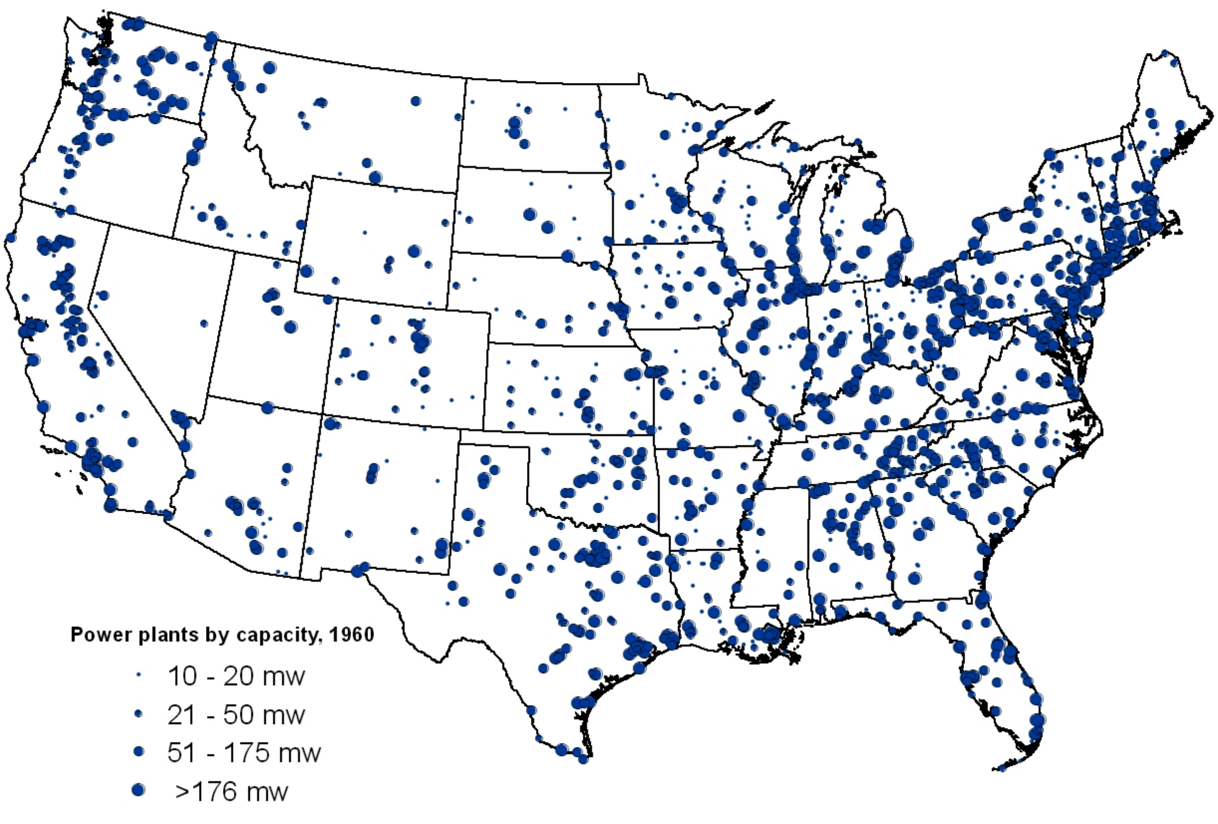


Figure 13: Change in proportion of households with lights, 1940-1950

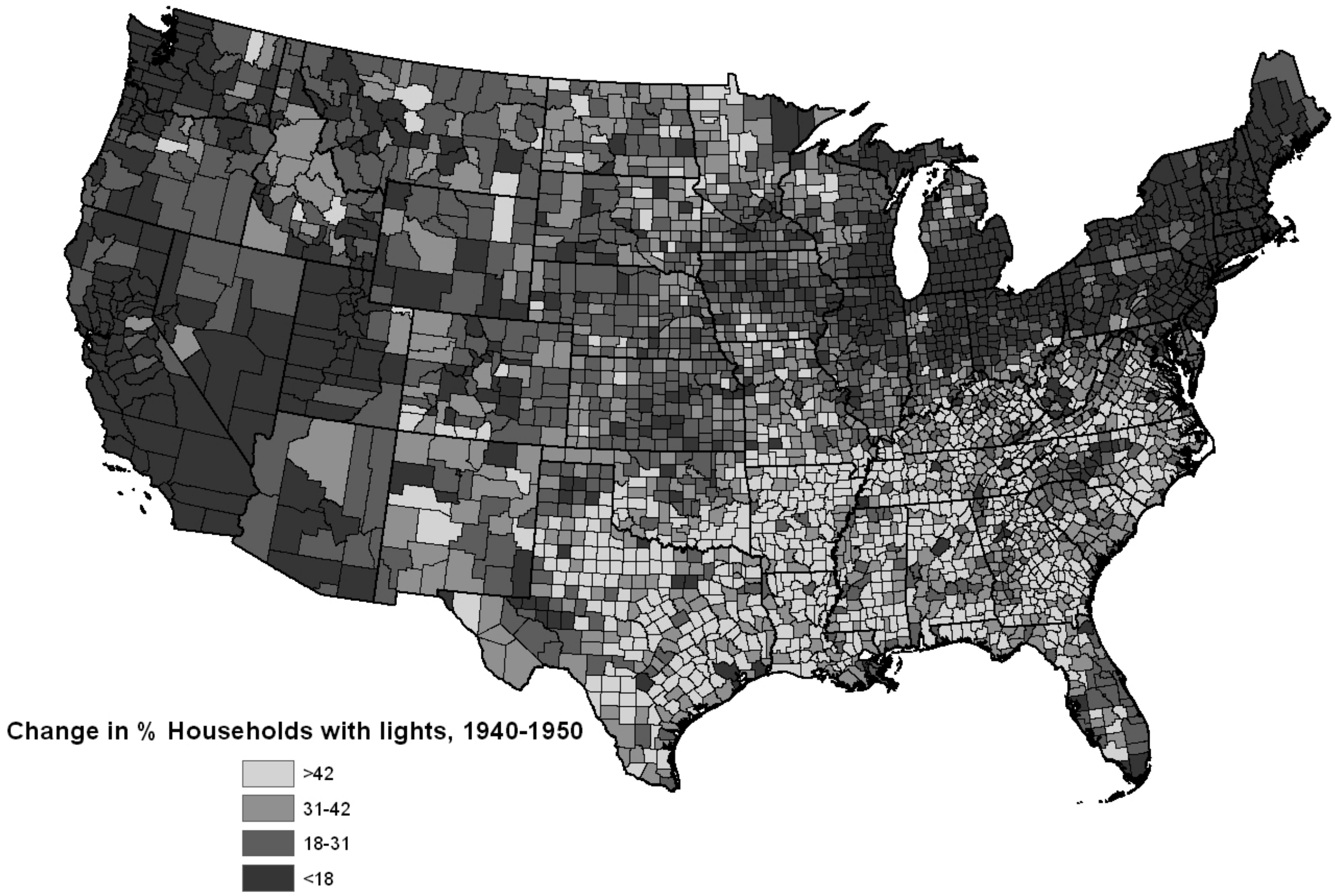


Figure 14: Change in proportion of households with modern stoves, 1940-1960

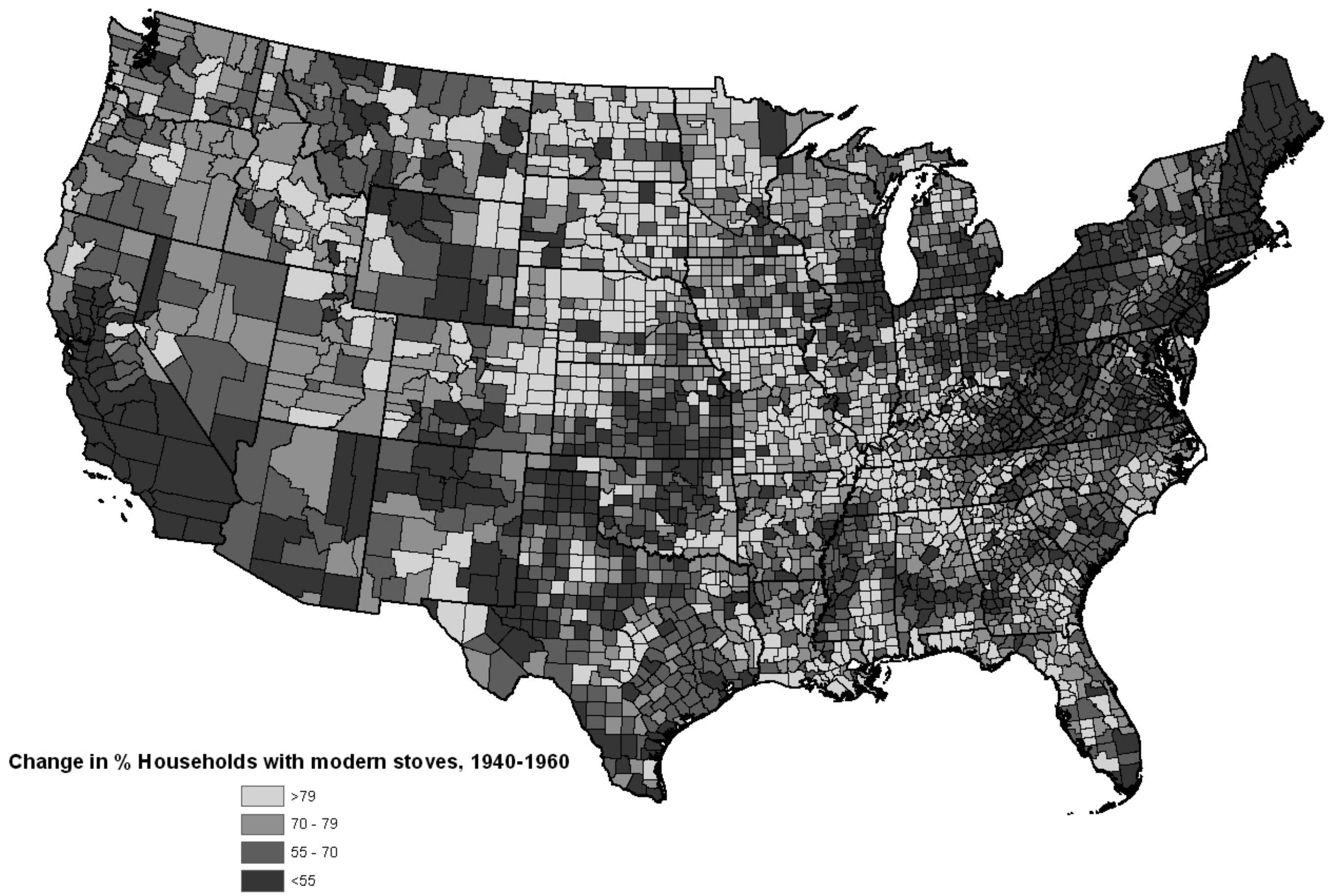


Figure 15: Change in proportion of households with refrigerators, 1940-1950

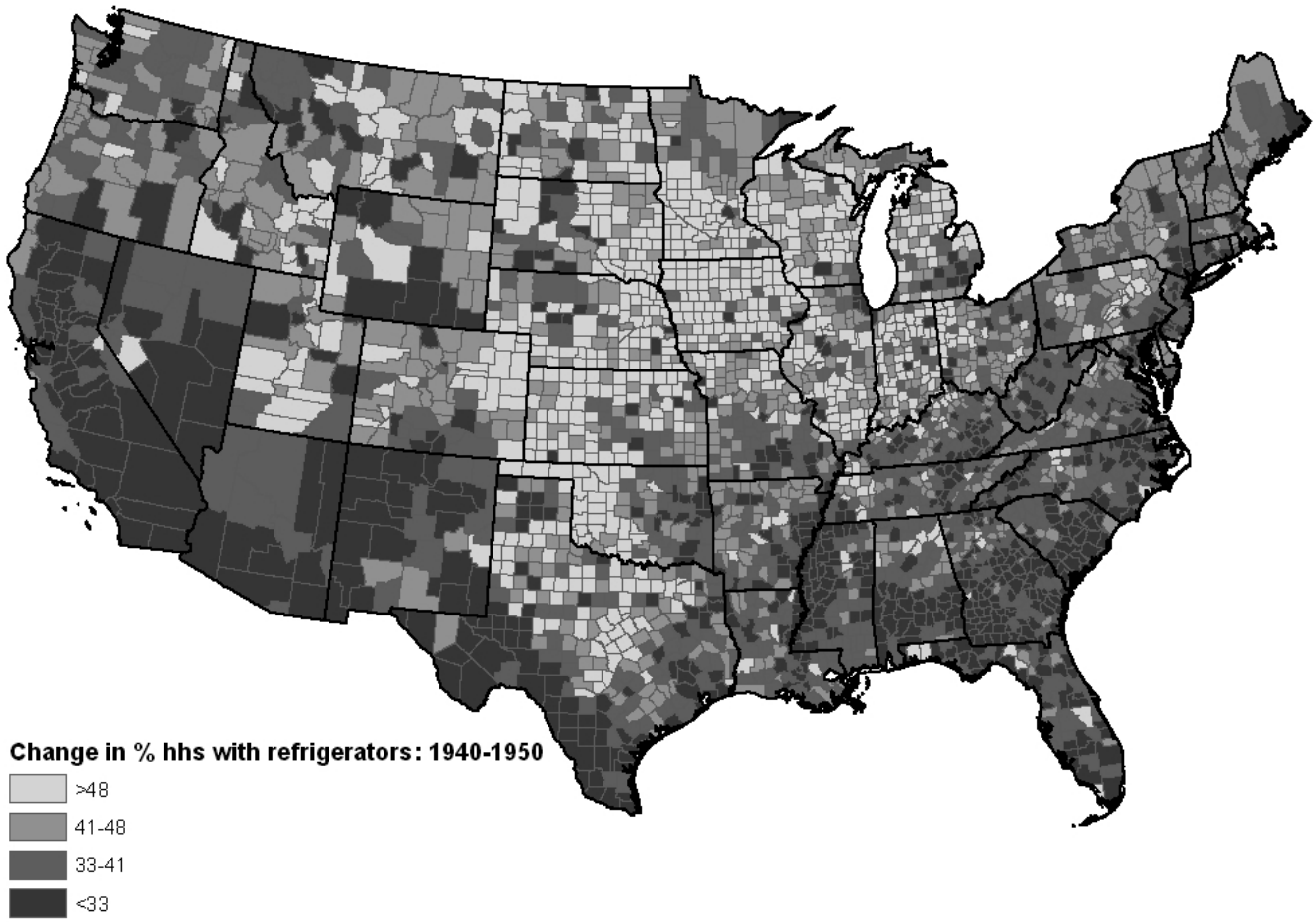


Figure 16: Change in county-distance to power plants, 1940-1960

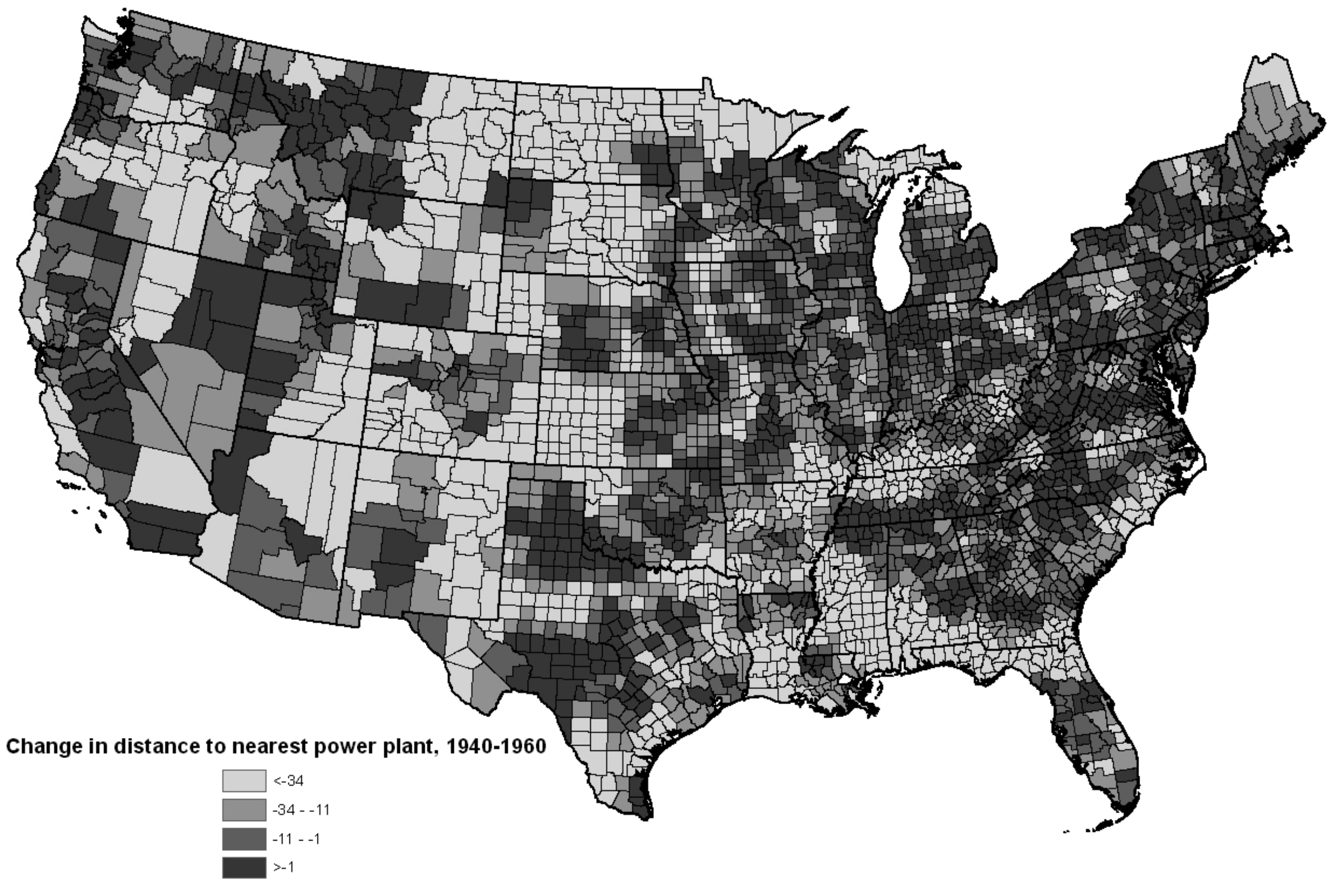


Figure 17: Change in proportion of households with lights, 1930-1960

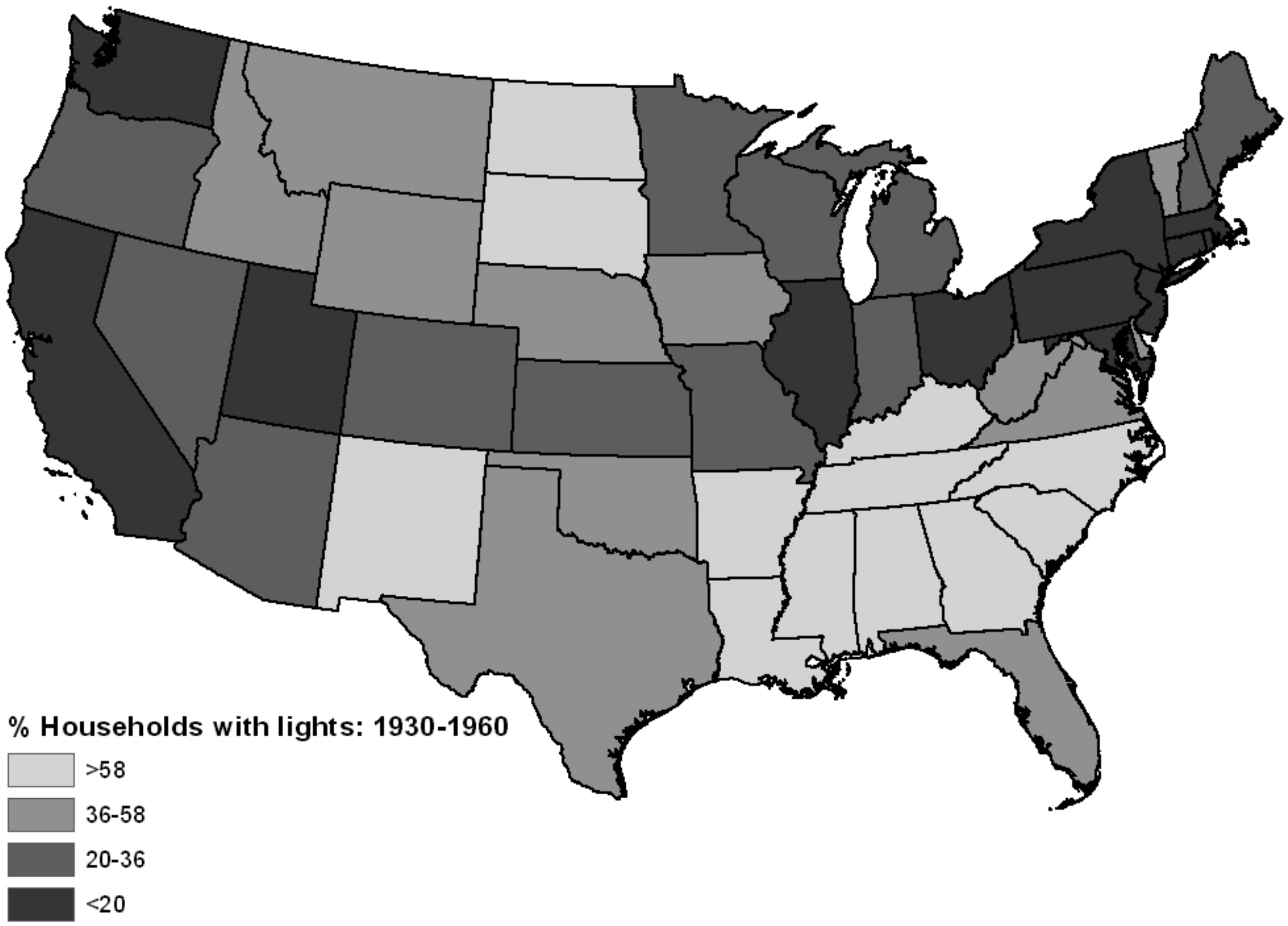


Figure 18: Change in average distance to power plants, 1930-1960

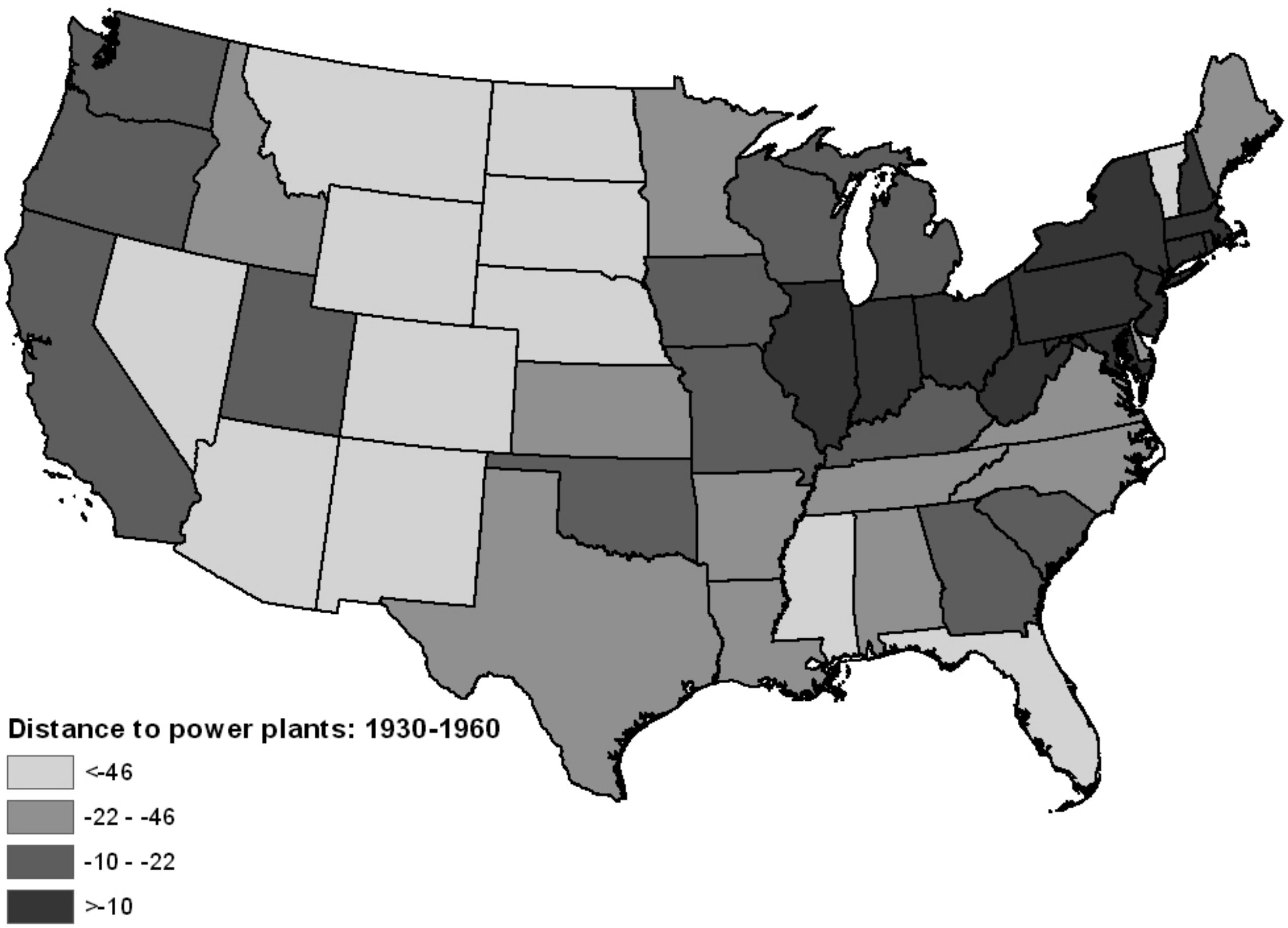


Figure 19: Households using coal, 1940

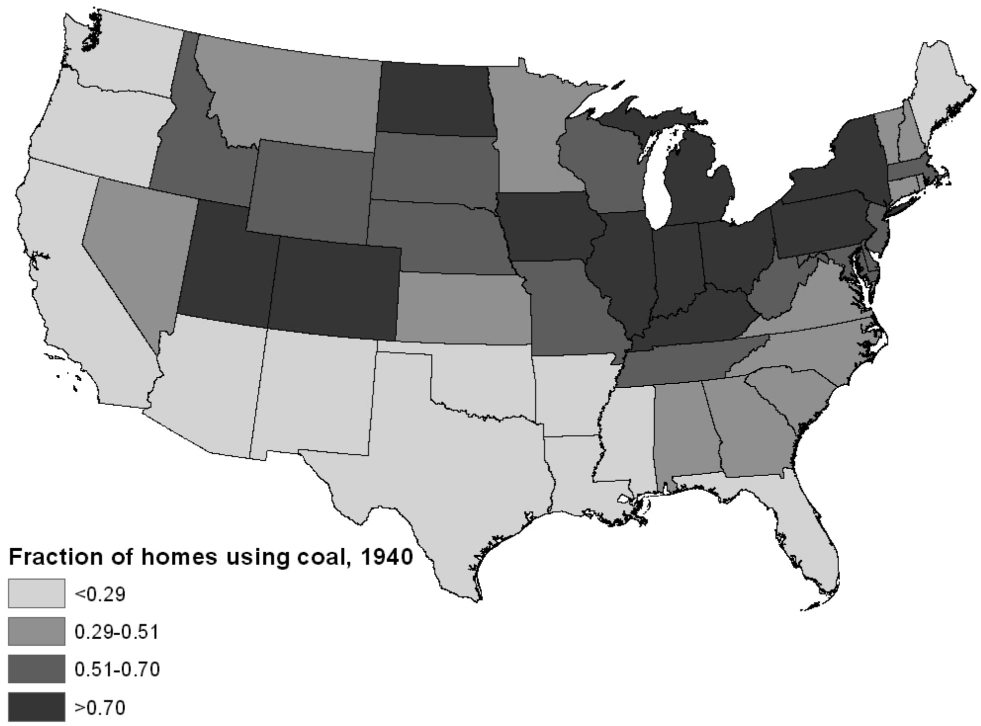


Figure 20: Fraction of Sheppard-Towner funds accepted

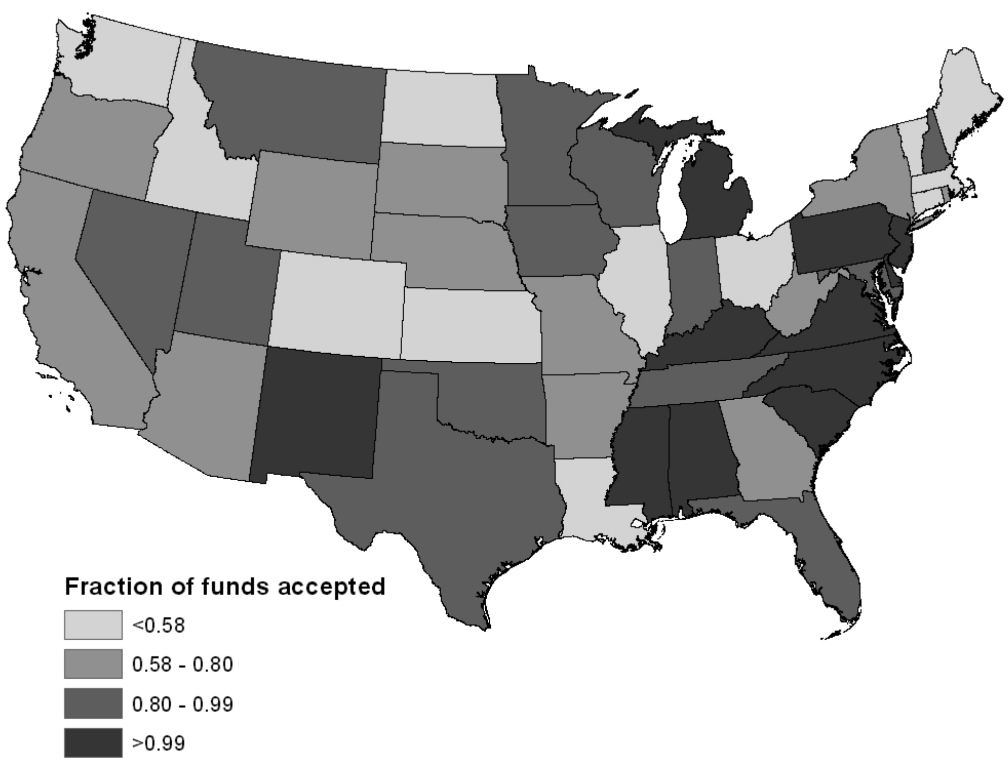


Figure 21: Residual plot

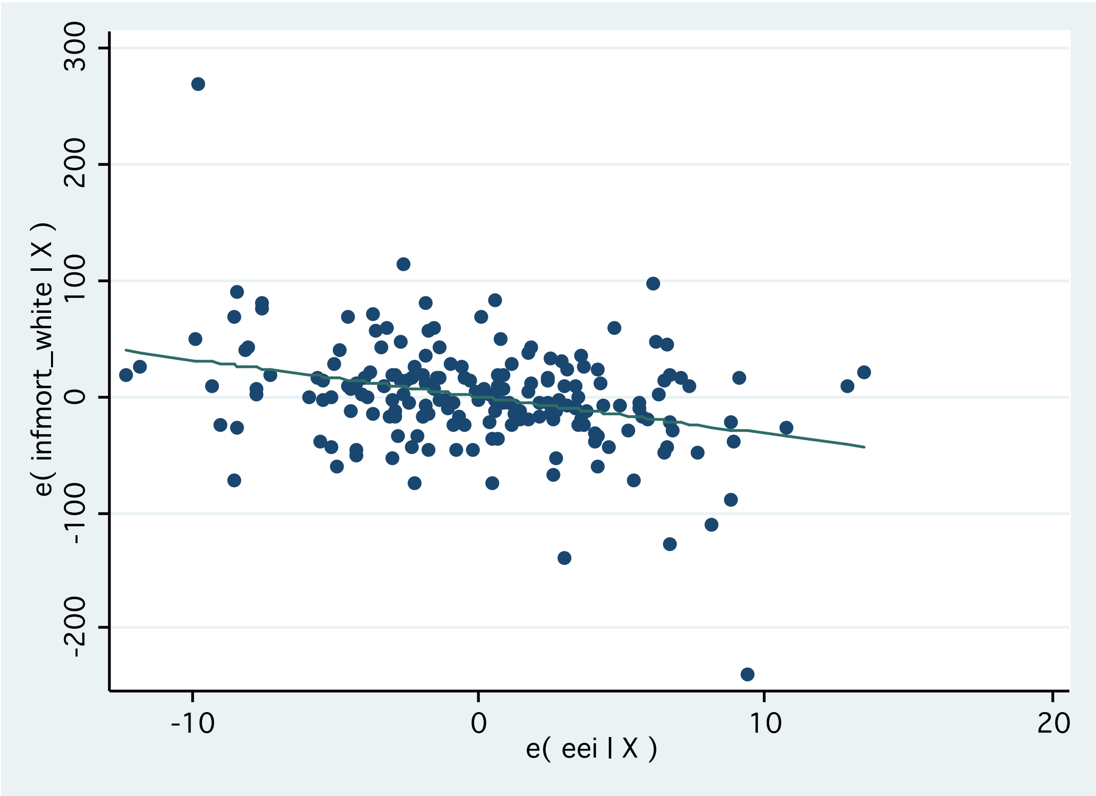


Table 1: Sample Means, county-level variables

School attendance	
Age 5-6	36.2
	[12.3]
Age 7-13	94.2
	[7.6]
Age 14-17	81.2
	[15.3]
Infant mortality (per 10,000 live births)	
Total	362.1
	[175.6]
Fertility	
Overall	98.1
	[24.9]
White	92.2
	[21.7]
Non-white	113.9
	[44.7]
Modern technology	
Pct lights	69.6
	[25.0]
Pct stove	55
	[33.6]
Pct refrigerator	47.2
	[25.6]
Average dist to nearest power plant	43.1
	[40.2]
Controls	
Pct non-white	11.7
	[17.7]
Pct urban	26.3
	[27.1]
Ln(population)	9.9
	[1.1]
Ln(density)	3.4
	[1.5]
Median school	8.8
	[1.8]

Notes: The table reports unweighted means across U.S counties (excluding Hawaii and Alaska). Standard deviations in parentheses. Fertility is calculated as the number of infants (aged < 1 year) per 1,000 females aged 14-44.

Table 2: Sample Means, state-level variables

Infant mortality (per 10,000 live births)	
Total	428.4
	[198.9]
White	393.2
	[185.1]
Rural	383.4
	[188.4]
Neonatal (total)	248.7
	[116.2]
Neonatal (white)	219.5
	[86.8]
Modern technology	
Pct lights	79.4
	[22.5]
Average distance to power plants	34.9
	[32.4]

Notes: The table reports unweighted means across U.S states (excluding Hawaii and Alaska). Standard deviations in parentheses.

Table 3: Summary statistics, US power plants

	Plant characteristics (N=1606)
Type	
Hydro	0.31
Steam	0.69
Ownership	
Private	0.68
Cooperative	0.03
Municipal	0.16
State	0.03
Federal	0.1
Opening year	1943 [1945]
Capacity (MW)	153.8 [51.4]

Notes: The table reports information on all US power plants (exclusive IC plants and plants with capacity $< 10mw$). Square brackets report median values.

Table 4: First stage results, county-level

Percent lights			
Distance to power plant	-0.0905***	-0.0731***	-0.0528***
	[0.0125]	[0.0124]	[0.00930]
Percent modern stoves			
Distance to power plant	-0.0865***	-0.0752***	-0.0540***
	[0.00906]	[0.00884]	[0.00854]
Percent refrigerators			
Distance to power plant	-0.00532	-0.00363	0.00662
	[0.00922]	[0.00924]	[0.00844]
Demographics	N	Y	Y
Year & County FE	Y	Y	Y
Region×year	N	N	Y

Notes: The table reports the estimates on $distance_{ct}$ from the first-stage regression. Each cell reports the point estimate from a different regression. Demographic covariates include percent non-white, percent urban, ln(population), ln(density), and median schooling. Standard errors are clustered at the state-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 5: First stage results, state-level

Average distance	-0.240***	-0.188***	-0.143***	-0.154***	-0.0990**	-0.120***
	[0.0475]	[0.0376]	[0.0421]	[0.0333]	[0.0403]	[0.0306]
Demographics	N	N	Y	Y	Y	Y
Maternal mortality	N	N	N	N	Y	Y
Year & State FE	Y	Y	Y	Y	Y	Y
Region×year	N	Y	N	Y	N	Y

Notes: The table reports the estimates on $avedistance_{st}$ from the first-stage regression. Each cell reports the point estimate from a different regression. Demographic covariates include percent non-white, percent urban, ln(population), ln(density), and median schooling. Standard errors are clustered at the county-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 6: First stage, State Economic Area (SEA) level

Percent lights			
Average distance	-0.452***	-0.250***	-0.171***
	[0.0703]	[0.0548]	[0.0437]
Percent stove			
Average distance	-0.344***	-0.209***	-0.151***
	[0.0597]	[0.0344]	[0.0340]
Percent refrigerator			
Average distance	-0.0914***	-0.0686***	-0.0495**
	[0.0295]	[0.0218]	[0.0231]
Demographics	N	N	Y
Year & SEA FE	Y	Y	Y
RegionXyear	N	Y	Y

Notes: The table reports the estimates on $avedistance_{st}$ from the first-stage regression. Each cell reports the point estimate from a different regression. Demographic covariates include percent non-white, percent urban, ln(population), ln(density), and median schooling. Standard errors are clustered at the SEA-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 7: Fertility

	OLS			IV		
Percent lights	-0.388***	-0.300***	-0.185***	-0.0492	0.0941	-0.0525
	[0.0258]	[0.0277]	[0.0349]	[0.113]	[0.135]	[0.171]
Demographics	N	Y	Y	N	Y	Y
Year & County FE	Y	Y	Y	Y	Y	Y
RegionXyear	N	N	Y	N	N	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variable is white fertility (number births per 1,000 women aged 18-44). Standard errors are clustered at the county-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 8: Fertility, by age group

	OLS			IV		
Age 18-34						
Pct lights	-0.000621**	-0.000492	-0.000639**	-0.000325	7.70e-05	8.81e-05
	[0.000299]	[0.000366]	[0.000248]	[0.000393]	[0.000802]	[0.00106]
Age 35-49						
Pct lights	-0.00142***	-0.00133***	-0.00129***	-0.00147***	-0.00146**	-0.00176*
	[0.000201]	[0.000193]	[0.000252]	[0.000325]	[0.000624]	[0.000937]
Demographic controls	N	N	Y	N	N	Y
SEA & Year FE	Y	Y	Y	Y	Y	Y
RegionXyear	N	Y	Y	N	Y	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variable is an indicator for whether a child age less than 5 is present. The model is estimated separately for women age 18-34 and 35-49. Standard errors are clustered at the SEA-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 9: School attendance

	OLS			IV		
Age 5-6						
Pct lights	0.00385***	0.00393***	0.00239***	0.00349***	0.00339***	0.00489***
	[0.000224]	[0.000255]	[0.000294]	[0.000946]	[0.00116]	[0.00155]
Age 7-13						
Pct lights	0.00149***	0.00145***	0.000289	0.00119*	0.00115	-0.000445
	[0.000150]	[0.000181]	[0.000204]	[0.000666]	[0.000829]	[0.00107]
Age 14-17						
Pct lights	0.00129***	0.00106***	0.000586***	0.00118**	0.000938	0.000204
	[0.000126]	[0.000144]	[0.000176]	[0.000514]	[0.000629]	[0.000863]
Demographics	N	Y	Y	N	Y	Y
Year & County FE	Y	Y	Y	Y	Y	Y
RegionXyear	N	N	Y	N	N	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variable is the proportion of children currently attending school (for each age group). Standard errors are clustered at the county-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 10: Gender gap in school attendance

	OLS			IV		
Age 5-6						
Pct lights	0.00196	0.00261	0.00236	0.00125	0.00245	0.00102
	[0.00131]	[0.00172]	[0.00203]	[0.00243]	[0.00460]	[0.00535]
Age 7-13						
Pct lights	0.000130	8.08e-05	0.000208	0.000237	2.02e-05	-0.000221
	[0.000353]	[0.000427]	[0.000512]	[0.000773]	[0.00136]	[0.00153]
Age 14-17						
Pct lights	0.000891	0.000486	-0.000200	-0.00422**	-0.00824*	-0.00866**
	[0.000891]	[0.00112]	[0.00137]	[0.00207]	[0.00431]	[0.00417]
Demographics	N	Y	Y	N	Y	Y
Year & SEA FE	Y	Y	Y	Y	Y	Y
RegionXyear	N	N	Y	N	N	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variable is calculated as the difference in attendance rate (male - female). Standard errors are clustered at the SEA-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 11: Infant mortality, county-level

	OLS			IV		
Pct lights	-0.206***	-0.133**	-0.0697	-0.494***	-0.500***	-0.708**
	[0.0409]	[0.0553]	[0.0663]	[0.124]	[0.173]	[0.282]
Demographics	N	Y	Y	N	Y	Y
Year & County FE	Y	Y	Y	Y	Y	Y
RegionXyear	N	N	Y	N	N	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variable is the infant mortality rate (number of infant deaths per 10,000 live births). The sample is restricted to counties with at least 500 live births in 1940. Standard errors are clustered at the county-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 12: White Infant mortality, state-level

	OLS				IV			
Total								
Pct lights	-1.545***	-2.507***	-2.426***	-3.199***	-4.019***	-4.877***	-3.996**	-5.139**
	[0.506]	[0.769]	[0.777]	[0.869]	[1.388]	[1.736]	[1.653]	[2.029]
Rural								
Pct lights	-1.136**	-2.094**	-2.210**	-2.722***	-4.256***	-6.845***	-6.221***	-7.891**
	[0.560]	[0.909]	[0.934]	[1.028]	[1.523]	[2.211]	[2.030]	[2.554]
Demographics	N	N	Y	Y	N	N	Y	Y
Maternal mortality	N	N	N	Y	N	N	N	Y
Year & State FE	Y	Y	Y	Y	Y	Y	Y	Y
RegionXyear	N	Y	Y	Y	N	Y	Y	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variable is the infant mortality rate (number of infant deaths per 10,000 live births). Standard errors are clustered at the state-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 13: Robustness checks: White Infant mortality, state-level

			Convergence		Additional covariates		
	(1) Baseline	(2) Add linear state trend	(3) Lagged dep variable	(4) Control for 1930 infant mortality	(5) Midwife birth rate	(6) Sheppard Towner	(7) Exclude Northeast & California
Infant mortality							
OLS							
Pct lights	-3.199***	-2.192***	-1.591***	-1.797**	-3.129***	-3.256*	-3.439*
	[0.869]	[0.690]	[0.424]	[0.741]	[0.928]	[0.883]	[1.037]
IV							
Pct lights	-5.139**	-3.359*	-1.979**	-2.765*	-5.366**	-4.976**	-5.439**
	[2.029]	[2.018]	[0.814]	[1.518]	[2.337]	[1.971]	[2.366]
Rural infant mortality							
OLS							
Pct lights	-2.722***	-2.192**	-1.476***	-1.280	-2.020*	-2.873***	-3.470***
	[1.028]	[0.896]	[0.370]	[0.912]	[1.107]	[1.046]	[1.162]
IV							
Pct lights	-7.891***	-5.438*	-1.637**	-4.786**	-8.175***	-7.575***	-8.458***
	[2.554]	[3.056]	[0.832]	[1.917]	[3.116]	[2.431]	[2.703]
Demographics	Y	Y	Y	Y	Y	Y	Y
Maternal mortality	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y
State FE	Y	Y	N	Y	Y	Y	Y
RegionXyear	Y	N	N	Y	Y	Y	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variable is the infant mortality rate (number of infant deaths per 10,000 live births). Standard errors are clustered at the state-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 14: Testing the exclusion restrictions, migration patterns

	OLS			IV		
Full Sample						
Pct lights	0.000834*	0.00136***	0.00159***	0.000546	0.000879	0.00102
	[0.000467]	[0.000481]	[0.000318]	[0.000654]	[0.000835]	[0.00141]
High Education						
Pct lights	0.00136**	0.00141**	0.00142***	8.11e-05	-0.00112	-0.00164
	[0.000629]	[0.000607]	[0.000488]	[0.000890]	[0.00129]	[0.00250]
Low Education						
Pct lights	0.000726	0.00157***	0.00180***	0.000893	0.00211*	0.00245
	[0.000520]	[0.000448]	[0.000371]	[0.000728]	[0.00108]	[0.00150]
Demographic controls	N	N	Y	N	N	Y
SEA & Year FE	Y	Y	Y	Y	Y	Y
RegionXyear	N	Y	Y	N	Y	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variable is an indicator for whether the individual migrated to the current SEA in the past 5 years in 1940 (or past year in 1950). The model is estimated for all men aged 25 to 59, and separately by education. Standard errors are clustered at the SEA-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 15: Testing the exclusion restrictions, male employment

	OLS			IV		
Age 25-34						
Pct lights	-0.000523**	-4.01e-05	-5.00e-05	-0.000892**	-0.000580	-0.000826
	[0.000259]	[0.000160]	[0.000221]	[0.000360]	[0.000648]	[0.000997]
Age 35-44						
Pct lights	-0.000475***	-0.000313**	-0.000510**	-7.04e-06	0.000641	0.00108
	[0.000152]	[0.000148]	[0.000245]	[0.000361]	[0.000809]	[0.00122]
Age 45-54						
Pct lights	-0.000948***	-0.000600*	-0.000253	-0.000947*	-0.000287	-9.55e-05
	[0.000333]	[0.000310]	[0.000280]	[0.000528]	[0.000944]	[0.00146]
Demographic controls	N	N	Y	N	N	Y
SEA & Year FE	Y	Y	Y	Y	Y	Y
RegionXyear	N	Y	Y	N	Y	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variable is an indicator an individual is currently employed. The model is estimated for men aged 25-34, 35-44, 45-54. Standard errors are clustered at the SEA-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 16: Testing the exclusion restrictions - Hospital quality

	OLS				IV			
Birth attended by midwife								
Pct Lights	-0.405***	-0.369***	-0.189***	-0.099	-0.303***	-0.446***	-0.328**	-0.337***
	[0.0449]	[0.0641]	[0.067]	[0.071]	[0.0850]	[0.116]	[0.131]	[0.124]
Neonatal mortality rate								
Pct Lights	-0.657***	-0.922***	-0.565	-0.732*	-0.598*	-0.715	-0.034	-0.028
	[0.176]	[0.292]	[0.359]	[0.401]	[0.324]	[0.526]	[0.694]	[0.678]
Demographics	N	N	Y	Y	N	N	Y	Y
Maternal mortality	N	N	N	Y	N	N	N	Y
Year & State FE	Y	Y	Y	Y	Y	Y	Y	Y
RegionXyear	N	Y	Y	Y	N	Y	Y	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variable is the proportion of births overseen by a midwife, and the neonatal mortality rate (number of infant deaths before 28 days per 10,000 live births). Standard errors are clustered at the state-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 17: Regional differences in white infant mortality, high-coal consuming states

	OLS				IV			
Infant mortality								
Baseline								
Pct lights	-1.545***	-2.507***	-2.426***	-3.199***	-4.019***	-4.877***	-3.996**	-5.139**
	[0.506]	[0.769]	[0.777]	[0.869]	[1.388]	[1.736]	[1.653]	[2.029]
High Coal								
Pct lights	-1.767**	-4.345***	-6.193***	-6.874***	-11.197***	-14.861***	-6.148***	-6.958**
	[0.865]	[1.535]	[1.520]	[1.604]	[3.899]	[5.625]	[2.557]	[2.847]
Rural infant mortality								
Baseline								
Pct lights	-1.136**	-2.094**	-2.210**	-2.722***	-4.256***	-6.845***	-6.221***	-7.891**
	[0.560]	[0.909]	[0.934]	[1.028]	[1.523]	[2.211]	[2.030]	[2.554]
High Coal								
Pct lights	-1.960**	-4.592**	-6.846***	-7.604***	-12.881***	-21.576**	-8.600***	-10.164***
	[0.933]	[1.726]	[1.596]	[1.665]	[4.349]	[9.515]	[2.782]	[3.179]
Demographics	N	N	Y	Y	N	N	Y	Y
Maternal mortality	N	N	N	Y	N	N	N	Y
Year & State FE	Y	Y	Y	Y	Y	Y	Y	Y
RegionXyear	N	Y	Y	Y	N	Y	Y	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variable is the infant mortality rate. 'High coal' states refer to the top two quartiles of domestic coal usage in 1940. Standard errors are clustered at the state-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 18: Regional differences in white infant mortality, high state-spending on maternal education programs

	OLS				IV			
Infant mortality								
Baseline								
Pct lights	-1.545***	-2.507***	-2.426***	-3.199***	-4.019***	-4.877***	-3.996**	-5.139**
	[0.506]	[0.769]	[0.777]	[0.869]	[1.388]	[1.736]	[1.653]	[2.029]
High spending								
Pct lights	-2.344***	-4.321***	-2.592*	-4.997**	-8.886***	-10.058***	-6.696**	-11.395**
	[0.797]	[1.170]	[1.434]	[1.801]	[2.585]	[2.546]	[2.996]	[4.692]
Rural infant mortality								
Baseline								
Pct lights	-1.136**	-2.094**	-2.210**	-2.722***	-4.256***	-6.845***	-6.221***	-7.891**
	[0.560]	[0.909]	[0.934]	[1.028]	[1.523]	[2.211]	[2.030]	[2.554]
High spending								
Pct lights	-2.125**	-4.163***	-2.348	-4.739**	-10.618***	-11.500***	-8.602***	-14.472***
	[0.925]	[1.378]	[1.693]	[2.070]	[3.385]	[3.077]	[3.354]	[5.261]
Demographics	N	N	Y	Y	N	N	Y	Y
Maternal mortality	N	N	N	Y	N	N	N	Y
Year & State FE	Y	Y	Y	Y	Y	Y	Y	Y
RegionXyear	N	Y	Y	Y	N	Y	Y	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variable is the infant mortality rate. 'High spending' states refer to the top two quartiles in Sheppard-Towner funds accepted between 1922 and 1929. Standard errors are clustered at the state-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 19: Other effects of household modernization: Female employment and marriage, by age

	OLS			IV		
Female Employment						
Age 18-34						
Pct lights	0.000381**	0.000450*	0.000405	7.40e-05	-0.000228	-0.000821
	[0.000175]	[0.000247]	[0.000254]	[0.000482]	[0.000861]	[0.00133]
Age 35-49						
Pct lights	-0.000124	0.000261	-0.000392	-0.00121**	-0.00161*	-0.00200
	[0.000269]	[0.000238]	[0.000374]	[0.000508]	[0.000928]	[0.00146]
Married						
Age 18-34						
Pct lights	-0.000586*	-0.000297	-0.000258	-0.000439	7.37e-05	0.000316
	[0.000308]	[0.000354]	[0.000215]	[0.000459]	[0.000894]	[0.00107]
Age 35-49						
Pct lights	0.000111	-0.000159	7.75e-05	0.000822**	0.000772	-1.70e-05
	[0.000192]	[0.000264]	[0.000254]	[0.000417]	[0.000806]	[0.000879]
Demographic controls	N	N	Y	N	N	Y
SEA & Year FE	Y	Y	Y	Y	Y	Y
RegionXyear	N	Y	Y	N	Y	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variables are indicators for individual employment and marital status. The model is estimated for women aged 18-34, and 35-49. Standard errors are clustered at the SEA-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 20: Other effects of household modernization: Intergenerational cohabitation

	OLS			IV		
Mother at home						
Age 25-34						
Pct lights	-3.64e-05	0.000103	-8.57e-05	-0.000552**	-0.000797*	-0.00146**
	[0.000119]	[9.72e-05]	[0.000141]	[0.000224]	[0.000447]	[0.000586]
Age 35-44						
Pct lights	0.000151	0.000180	0.000197	7.55e-05	7.85e-05	-3.91e-05
	[0.000111]	[0.000158]	[0.000206]	[0.000257]	[0.000497]	[0.000709]
Age 45-54						
Pct lights	-3.56e-05	5.43e-05	0.000261	9.51e-06	0.000122	0.000112
	[0.000101]	[0.000133]	[0.000162]	[0.000290]	[0.000567]	[0.000852]
Living with a child						
Age 50-59						
Pct lights	-0.000598*	-0.000192	-6.23e-05	-0.000723	-0.000345	-0.000306
	[0.000306]	[0.000314]	[0.000397]	[0.000748]	[0.00138]	[0.00228]
Age 60-69						
Pct lights	-0.00159***	-0.000922**	0.000211	-0.00364***	-0.00522***	-0.00679**
	[0.000401]	[0.000417]	[0.000583]	[0.000861]	[0.00184]	[0.00287]
Age 70+						
Pct lights	-0.000534	-0.000559	-2.84e-05	3.37e-05	0.000660	0.00224
	[0.000430]	[0.000564]	[0.000675]	[0.00113]	[0.00202]	[0.00306]
Demographic controls	N	N	Y	N	N	Y
SEA & Year FE	Y	Y	Y	Y	Y	Y
RegionXyear	N	Y	Y	N	Y	Y

Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The dependent variables are an indicator for whether a mother is living in the same home, an indicator for a 3+ generational home, and an indicator for whether an older woman is living with her child. Standard errors are clustered at the SEA-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

A Appendix

Table A.1: First stage - county level: Percent households with lights

Distance (baseline)	-0.0905*** [0.0125]	-0.0731*** [0.0124]	-0.0528*** [0.00930]
Distance (includes small and IC plants)	-0.258*** [0.0303]	-0.178*** [0.0309]	-0.100*** [0.0237]
Distance dummies			
I(D< 10 miles)	5.426** [2.127]	6.775*** [1.974]	2.417 [1.555]
I(10 < D < 20 miles)	11.54*** [1.593]	8.786*** [1.489]	4.550*** [1.244]
I(20 < D < 30 miles)	13.43*** [1.351]	9.631*** [1.287]	5.507*** [1.052]
I(30 < D < 40 miles)	10.71*** [1.305]	8.291*** [1.274]	4.507*** [1.039]
I(40 < D < 50 miles)	8.230*** [1.302]	6.124*** [1.233]	3.092*** [1.016]
I(50 < D < 60 miles)	5.312*** [1.331]	4.399*** [1.268]	2.824*** [1.028]
Distance dummies (Includes small plants & IC plants)			
I(D< 10 miles)	14.94*** [2.150]	10.29*** [2.265]	4.921*** [1.863]
I(10 < D < 20 miles)	18.65*** [1.993]	12.44*** [2.082]	5.893*** [1.718]
I(20 < D < 30 miles)	15.41*** [1.887]	10.96*** [1.963]	4.593*** [1.663]
I(30 < D < 40 miles)	11.61*** [1.893]	7.928*** [2.003]	2.647 [1.666]
I(40 < D < 50 miles)	6.130*** [2.068]	4.037* [2.092]	0.346 [1.723]
I(50 < D < 60 miles)	3.155 [2.140]	1.521 [2.271]	0.0521 [1.866]
Ln(capacity)	4.208*** [0.520]	3.458*** [0.492]	1.334*** [0.414]
Demographics	N	Y	Y
Year FE	Y	Y	Y
County FE	Y	Y	Y
RegionXyear	N	N	Y

Table A.2: First stage - county level: Percent households with modern stoves

Distance (baseline)	-0.0865***	-0.0752***	-0.0540***
	[0.00906]	[0.00884]	[0.00854]
Distance (includes small and IC plants)	-0.175***	-0.129***	-0.114***
	[0.0220]	[0.0218]	[0.0207]
Distance dummies			
I(D< 10 miles)	1.851	1.976	2.109*
	[1.306]	[1.257]	[1.215]
I(10 < D < 20 miles)	6.913***	5.032***	4.472***
	[1.090]	[1.059]	[1.014]
I(20 < D < 30 miles)	6.386***	4.298***	3.465***
	[0.936]	[0.931]	[0.883]
I(30 < D < 40 miles)	5.151***	3.561***	2.823***
	[0.864]	[0.866]	[0.817]
I(40 < D < 50 miles)	3.679***	2.764***	2.235***
	[0.883]	[0.888]	[0.833]
I(50 < D < 60 miles)	3.063***	3.169***	2.602***
	[0.947]	[0.961]	[0.864]
Distance dummies (Includes small plants & IC plants)			
I(D< 10 miles)	9.436***	7.219***	6.221***
	[1.638]	[1.598]	[1.517]
I(10 < D < 20 miles)	9.156***	5.845***	6.123***
	[1.531]	[1.506]	[1.438]
I(20 < D < 30 miles)	4.944***	2.588*	3.277**
	[1.428]	[1.414]	[1.344]
I(30 < D < 40 miles)	2.841**	1.091	1.603
	[1.434]	[1.420]	[1.346]
I(40 < D < 50 miles)	0.924	-0.102	0.607
	[1.501]	[1.490]	[1.403]
I(50 < D < 60 miles)	0.228	-0.0107	0.394
	[1.680]	[1.723]	[1.605]
Ln(capacity)	1.655***	1.238***	1.055***
	[0.271]	[0.262]	[0.257]
Demographics	N	Y	Y
Year FE	Y	Y	Y
County FE	Y	Y	Y
RegionXyear	N	N	Y

Table A.3: First stage - county level: Percent households with modern refrigerators

Distance (baseline)	-0.00532	-0.00363	0.00662
	[0.00922]	[0.00924]	[0.00844]
Distance (includes small & IC plants)	-0.0341*	-0.0297	-0.0446**
	[0.0206]	[0.0210]	[0.0199]
Distance dummies			
I(D< 10 miles)	-2.646**	-1.435	-0.949
	[1.324]	[1.290]	[1.167]
I(10 < D < 20 miles)	-0.412	-0.357	0.0365
	[1.124]	[1.103]	[0.985]
I(10 < D < 20 miles)	-0.848	-1.182	-0.653
	[1.006]	[1.000]	[0.882]
I(10 < D < 20 miles)	-2.097**	-2.064**	-1.444
	[1.005]	[1.012]	[0.897]
I(10 < D < 20 miles)	-1.661*	-1.740*	-1.571*
	[0.990]	[0.977]	[0.851]
I(10 < D < 20 miles)	0.313	-0.00115	-0.00908
	[1.057]	[1.022]	[0.904]
Distance dummies (Includes small plants & IC plants)			
I(D< 10 miles)	2.568	2.151	2.674*
	[1.583]	[1.583]	[1.553]
I(10 < D < 20 miles)	-0.710	-1.420	1.197
	[1.466]	[1.485]	[1.473]
I(10 < D < 20 miles)	-2.753**	-3.507**	-0.432
	[1.403]	[1.412]	[1.407]
I(10 < D < 20 miles)	-3.368**	-4.021***	-1.465
	[1.411]	[1.426]	[1.412]
I(10 < D < 20 miles)	-2.667*	-3.470**	-1.448
	[1.445]	[1.478]	[1.442]
I(10 < D < 20 miles)	-1.179	-1.375	-0.0697
	[1.680]	[1.700]	[1.615]
Ln(capacity)	-0.806**	-0.579	-0.169
	[0.356]	[0.358]	[0.331]
Demographics	N	Y	Y
Year FE	Y	Y	Y
County FE	Y	Y	Y
RegionXyear	N	N	Y