The short-run and long-run effects of household technological change *

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Abstract

This paper studies how advances in home production technologies affect female employment and investment in children. To study these relationships, I develop a Beckerian model of home production. I show that household modernization has an ambiguous immediate impact on female employment, but generates increased investment in daughters' human capital, ultimately causing a rise in employment for subsequent cohorts of women. I examine these predictions empirically, exploiting substantial cross-county and cross-state variation in the timing of household electrification in the U.S. for the period 1930 to 1960. To address potential endogeneity in the decision to modernize, I estimate instrumental variables regressions, based on a newly assembled dataset that provides information on the construction of over 1,000 power plants during this period. Identification relies on plausibly exogenous changes in the cost of supplying power to different communities based on their location. The empirical results support this intergenerational mechanism. Household electrification had no immediate impact on female employment, but is associated with increased school attendance, particularly among teenage daughters. Meanwhile, females raised in modern households were significantly more likely to work as adults. The results suggest that the diffusion of modern technology into the home during the first half of the 20th century can account for a large fraction of the rise in female employment after 1950.

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1 Introduction

One of the most significant changes to U.S. labour market during the 20th century was the increased participation of married women. In 1900, fewer than 6% of married women engaged in paid work. By 2000, their participation rate was over 60% (Historical Statistics of the United States, 1976, pp.133; Bureau of Labor Statistics). Female employment rose throughout the 20th century, however, the growth was much faster during the latter half. More than three quarters of the rise in the participation rate took place after 1940.

One explanation for the rise in female labour force participation is technological change within the home. Between 1930 and 1960, most families began acquiring modern household appliances. Greenwood, Seshadri, and Yorukoglu (2005) argue that these labour-saving appliances liberated women from domestic work, allowing them to enter the labour market. However, the empirical support for this claim has been mixed. In a cross-county fixed effects framework, Cardia (2011) finds limited evidence that the diffusion of modern appliances was correlated with increases female labour force participation for the period 1940 to 1950.[1] Moreover, despite the remarkable shift in the technology of housework, time spent in home production did not decline until the 1970s, nearly 40 years after families first adopted modern appliances (Francis and Ramey, 2009).

In this paper, I present new evidence on the relationship between household modernization and female employment. To motivate the empirical analysis, I introduce a Beckerian model of home production, in which modern household technologies permanently decreases the time-demand of housework, expanding the time-budget constraint of mothers.[2] The framework predicts that household modernization will have an ambiguous immediate impact on female employment, but generate increased investment in daughters' human capital,

[1] On the other hand, Coen-Pirani, León, and Lugauer (2010) find that household modernization contributed to the increases in married women's employment between 1960 and 1970. Similarly, Dinkelman (2011) finds that the diffusion of electricity in rural South Africa led to increased participation rates.

[2] I abstract from fathers' home production decisions. During this period, men accounted for less than 15% of total hours spent in home production (Ramey, 2009).

which ultimately leads to a rise in employment for subsequent cohorts.[3]

I examine the predictions of the model empirically. To study the initial (short-run) response to household technological change, I relate changes in household electrification rates to contemporaneous changes in female employment and school attendance using county-level panel data. I also study the second generation (long-run) response to household technological change, using information on state-of-birth and year-of-birth to construct a measure of access to modern technology during childhood. This measure is related to long-term employment outcomes.

Unobservable family characteristics – such as wealth – may simultaneously influence the adoption of appliances and the mother's decision to enter the labour force, which would bias the baseline estimates. To address potential endogeneity in the diffusion of modern household technology, I adopt an instrumental variables (IV) approach, based on the construction of more than 1,000 power plants between 1930 and 1960. I exploit the fact that power plants were more likely to supply electricity to nearby communities, using changes in county distance to power plants as an instrument for changes in household electrification and appliance ownership. This approach requires that decisions about the location of plants were made independently of time varying determinants of female employment and school attendance. That power plant location was exogenous is supported by geographical constraints, the long lifespan of power plants, and historical evidence on how sites were chosen.

The results suggest that household electrification had virtually no immediate impact on female employment. In both OLS and IV regressions, the point estimates for the contemporaneous effects on female employment are small and statistically insignificant. On the other hand, household electrification is associated with increased investment in children, as measured by school attendance. It also generated a differential increase in female school attendance, consistent with parental investments having been targeted towards daughters.

[3]These results are analogous to Albanesi and Olivetti (2011), who find that a permanent decline in the U.S. maternal mortality rate led to a temporary rise in fertility and female human capital investment, which then led to a second generation decline in fertility.

Turning to the long-run impact of household modernization, I find that childhood access to electricity is associated with long-term increases in female employment. In the preferred specification, a one standard deviation (20 percentage point) increase in the proportion of homes with electricity in the home state raises the probability of future employment by 6%. Access to electricity is also associated with a significant increase in weekly hours worked and personal income. On the other hand, household electrification has almost no effect on the long-run labour-market outcomes of men, suggesting that the results are not driven by economic development or infrastructure investment associated with local electrification.

To conclude the empirical analysis, I examine the mechanisms driving the increases in female employment. The results do not appear to have been caused by declines in fertility or lower marriage rates. They also cannot be attributed to increases in completed female schooling due to household electrification. Instead, the rise in female employment appears to have been due to informal investments in daughters. For example, Schwartz Cowan (1983) argues that household technological change led mothers to take over many of the domestic duties that had been the responsibility of teenage daughters. The results may also have been expectation-driven, as younger female cohorts updated their beliefs about the likelihood of future employment. Consistent with this explanation, Goldin (2005) shows that beginning with cohorts born during the 1940s, expectations of young women regarding future employment rose dramatically.

This research contributes to the literature on the impact of technological change within the home. Greenwood, Seshadri, and Vandenbroucke (2005) and Greenwood, Seshadri, and Yorukoglu (2005) calibrate general equilibrium models to study the effects of household technological change on fertility and female labour force participation. Bailey and Collins (2011) and Cardia (2011) examine these relationships empirically in a cross-county fixed effects framework. The results help reconcile the observations that household technological change substantial reduced the demands of basic housework, but had no immediate effect on time spent in home production. It was not until the mid-1960s, as the second generation of women began entering the labour market, that hours spent in home production began to fall. The results also demonstrate that the immediate impact of household modernization on female employment was substantially smaller than its long-term effect, a finding that has relevance for current studies in the developing world (see Dinkelman, 2011, for example).

This research also contributes to the larger literature on the determinants of female labour force participation throughout the 20th century. Increases in the demand for clerical workers and a greater supply of high school graduates drove the increases in female employment during the first half of the 20th century (Goldin, 1990). The elimination of marriage bars and greater availability of part time employment opportunities also facilitated the rise in participation among married women beginning in the 1940s (Goldin, 1991, 2006). World War II led increases in participation (Goldin, 1991; Acemoglu, Autor, and Lyle, 2004; Goldin and Olivetti, 2013), and had persistent effects on the social norms regarding female employment (Fernandez, Fogli, and Olivetti, 2004). The birth control pill and in vitro fertilization have also been linked to increased participation for younger women (Goldin and Katz, 2002; Bailey, 2006; Buckles, 2005). Such determinants of female employment may have been reinforced by household modernization. As women were liberated from the demands of domestic work, they may have been better able to respond to the incentives of engaging in paid work.

The paper proceeds as follows: Section 2 discusses the history of household modernization in the U.S.; Section 3 presents the conceptual framework; Section 4 presents the empirical strategy; Section 5 describes the data; Section 6 reports the results from both the short-run and long-run analysis; and Section 7 concludes.

2 Historical context

2.1 The diffusion of electricity & modern appliances into the home

Industrial use of electricity was common by the early 20th century, but a number of factors delayed the diffusion of electricity and modern appliances into the home. The high price and low quality of early appliance models limited adoption into the 1920s (Tobey, 1996). Homeowners also needed to retrofit homes for electricity, which added to the cost of acquiring major modern appliances.[4] Electric utility companies were responsible for the costs of connecting new customers to the grid. Because so few households could afford large appliances, the electricity consumption of domestic users often did not cover the carrying cost, so private companies were reluctant to supply homes with power. The failure of private industry to provide electricity to households was particularly acute in rural areas, where the cost of adding a new customer to the grid was higher.

The barriers to household modernization began disappearing in the 1930s. As industry demand for power declined during the depression, utility companies turned to domestic consumers as a new sources of revenue.[5] Meanwhile, increased regulation of the electric utilities led to falling electricity prices throughout the 1930s and 1940s. Government projects, such as the Rural Electrification Administration, also began supplying power to rural customers beginning in the mid-1930s.

At the same time that electrical services were being rolled out to new customers, more families were able to purchase modern electric appliances. Beginning in the 1930s, appliance prices began to decline, and second generation models were far more reliable (Tobey, 1996). In 1934, the Federal Housing Administration (FHA) started offering federal insurance for household modernization loans. These loans covered the purchase of modern appliances and the installation of heavy wiring. Within three years, nearly 15% of households had take advantage of this program.

Figure 1(a) reports the proportion of homes with electricity, running water, flush toilets, and central heating from 1890 to 1970. Widespread adoption began about 1920, with almost

[4]The cost of retrofit varied with the type of wiring. Basic lighting could be provided with exposed wiring. Heavy appliances were required to be on a separate circuit with larger wiring. In kitchens with indoor plumbing, wiring was required to be sealed to prevent water damage. The cost of retrofitting for for wiring and fixtures was estimated to be $70 (*Electrical World*, 1931).

[5]An article in a leading industry manuel 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*, 1935).

universal ownership by 1960. There were large urban-rural differences in the *timing* of modernization. Figure 1(b) reports the proportion of rural households with basic facilities. In 1930, most urban homes had electricity, in contrast to fewer than 10% of rural households. Over the next 30 years, the urban-rural gap in household electrification rates disappeared; by 1960, the proportion of rural homes with electricity was over 95%. For rural customers, electricity usually provided access to pumped water, and from 1930 to 1960, the proportion of rural homes with running water rose from less than 20% to over 90%.

Household electrification brought families access to a variety of new consumer durables. Figure 1(c) reports the proportion of homes with a washing machine, mechanical refrigerator, vacuum, and modern range. Between 1930 and 1960 there was a dramatic increase in ownership of electric appliances. For example, the proportion of homes with a modern refrigerator increased from less than 10% in 1930 to 80% in 1950. The increased use of these modern technologies is reflected in electricity consumption. In the early 1920s, the average family with electricity used less than 30 kwh per month, little more than was necessary for basic lighting. By 1960, families consumed over 300 kwh per month, enough to power several major modern appliances (Historical Statistics of the U.S., 1976).

2.2 Changes in time spent in home production

Household electrification and the diffusion of modern appliances dramatically reduced the burden of basic housework. 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., 2005). Without electricity to pump water into homes, rural housewives needed to collect well-drawn water. One federal study found that the average farm used 40 gallons of well-drawn water per person per day, and that the average well was over 250 feet from the house (Luff, 1940). 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).

Figure 2 reports the weekly hours spent in home production between 1920 and 1960. These estimates are based on a compilation of a variety of time-use diaries (see Francis and Ramey, 2009). Despite a substantial decline in the demands of basic housework, female time spent in home production fell by less than three hours per week between 1920 and 1960. These trends may reflect the fact that barriers to labour market entry limited the ability of married women to reallocate time to market work (see Goldin, 2006). Similarly, the first generation of women to acquire labour-saving appliances likely made schooling decisions without knowledge of these new goods, which may have limited the return to paid work. On the other hand, Mokyr (2000) argues that modern appliances allowed families to shift time away from basic housework towards childcare and household hygiene, leaving total time spent in home production unchanged.[6]

Figure 3 reports time spent in home production for teenage females and males. Between 1920 and 1960, female time spent in home production fell by 5 hours per week, while there was no change for males. Meanwhile, weekly hours devoted to school rose more than doubled during this period. Along with Figure 2, these results support Schwartz Cowan (1983), who argues that household technological change led mothers to take over many of the domestic duties that had been the responsibility of teenage daughters.

3 Conceptual framework

I present a simple framework to examine how improvements in household technology affect female labour force participation and investment in daughters' human capital. I consider an environment inhabited solely by women, in which each adult female has a single daughter. A generalized version of this model – in which adult males work full time and investment can be directed towards either sons or daughters – delivers the same qualitative predictions.

[6]See Lewis (2013) for the effects of household modernization on infant health.

Let $T(z)$ denote the *net of home production* time endowment. This endowment reflects the amount of time available to a mother after basic household tasks are completed. I assume that $T(z)$ is increasing in level of technology, z.[7] A mother's time can be spent either in market work, l, or investment in her daughter's human capital, e'. She derives utility from her own consumption and the wellbeing of her daughter. She faces the following budget constraint for her consumption:

$$c \leq w(1 + \epsilon e) \cdot l \tag{1}$$

Where c denotes her own consumption, l denotes the amount of time spent in paid work, and w is the wage. The mother's level of human capital, e, is determined by the investments made be *her* mother when she was young. The parameter $\epsilon \geq 0$ captures the return to human capital.

A mother can also choose to allocate time to investment in daughter's human capital. Denote τ as the fraction of her time endowment required to make an investment in daughter's human capital. Thus, to raise a daughter with human capital e', a mother allocate a fraction $\tau e'$ of her time endowment to child investment.[8] As a result, she faces the following time budget constraint:

$$l + \tau e' \leq T(z) \tag{2}$$

Combining constraints (1) and (2) and substituting for c, the mother's problem can be written recursively according to the following Bellman equation:

[7]The level of technology is taken as exogenous, in order to correspond with the empirical analysis, which is based upon quasi-experimental variation in access to modern appliances rather than the endogenous decision of whether to purchase them. This setup also abstracts from decisions over home produced goods. A framework in which preferences over home produced goods become satiated would deliver the same predictions (Jones, Manuelli, and McGratton, 2003). On the other hand, Mokyr (2000) considers a framework in which families may choose to devote time towards improving the *quality* of home production goods, for example, by allocating time to the improvement of household hygiene practices or to infant care. The present setup allows mothers to choose to allocate time to improvements home production quality, provided that home production quality is capitalized into daughter's human capital.

[8]Notice that τ is simply the inverse of the productivity of time spent in child investment, t. This formulation implicitly assumes constant returns to maternal time in the production of daughter's human capital ($e' = \frac{1}{\tau} \cdot t$). Allowing for decreasing returns to maternal time (e.g. $e' = f(t)$ where $f'(\cdot) > 0$ and $f''(\cdot) \leq 0$) will not change the qualitative predictions of the model.

$$V(e,T(z)) = \max_{e' \geq 0} \{u(\, w(1+\epsilon e)[T(z) - \tau e'] \,) + \beta V(e', T'(z'))\} \tag{3}$$

The function $u(\cdot)$ is the utility from the mother's consumption. This function is assumed to be twice continuously differentiable with $u'(\cdot) > 0$ and $u''(\cdot) < 0$. The mother's value function $V(e, T(z))$ depends on her level of human capital, e, and the time constraint, $T(z)$.

The first order necessary conditions for the mother's problem are given by

$$-u'\left(w(1+\epsilon e)[T(z) - \tau e']\right) \cdot w(1+\epsilon e)\tau + \beta V_{e'}(e', T'(z')) \leq 0 \tag{4}$$

which hold with equality when $e' > 0$. The second term, $\beta V_{e'}(e', T'(z'))$, captures the marginal benefit associated with an increase daughter's human capital. A higher level of e' increases her daughter's consumption, a benefit that is discounted by a factor of β. The first term captures the marginal cost associated with human capital investment. For each additional unit of human capital investment, a mother must reduce the amount of time spent in paid work by τ, which leads to a loss in current income of $w(1+\epsilon e)\tau$. This forgone income is valued at $u'(c)$. The envelope condition is given as follows:

$$V_e(e, T(z)) = u'\left(w(1+\epsilon e)[T(z) - \tau e']\right) \cdot w\epsilon l \tag{5}$$

Together, equations (4) and (5) define unique functions for employment, $l(e, T(z))$, child investment, $e'(e, T(z))$, and future daughter's employment, $l'(e'(e, T(z)), T'(z'))$.

Assumption 1 *Household modernization leads to an exogenous expansion of the time budget constraint, $T(z)$, for current and future generations of women.*

Assumption 2 *Preferences over consumption exhibit a sufficient elasticity of substitution. In particular:*

$$\frac{-u''(c) \cdot c}{u'(c)} \leq 1.$$

Assumption 1 captures the idea that once a technology is adopted, it is available to all future generations. Assumption 2 captures the willingness of families to substitute consumption across generations.[9] This elasticity of substitution plays a critical role in determining how families respond to changes in the time endowment. To illustrate, consider the effect of an expansion to the daughter's time endowment, $T'(z')$. On the one hand, the shock to $T'(z')$ raises the return to human capital investment, since a daughter will have more time to earn income in the future. On the other hand, the shock leads to higher future income levels, which creates an incentive to *reduce* human capital investment in order to increase current consumption. Assumption 2 ensures that first (substitution) effect will dominate the second (income) effect, so that an increase in $T'(z')$ will lead to higher levels of human capital investment.

I now examine the impact of household modernization on mother's employment, $l(e, T(z))$, child investment, $e'(e, T(z))$, and daughter's employment, $l'(e'(e, T(z)), T'(z'))$.

Proposition 1 *Assume that mothers and daughters initially face the same time constraint, so that $T(z) = T'(z')$. Under Assumptions 1 and 2, the impact of permanent increase in the level household technology, z, on human capital investment, mothers' employment, and daughters' employment are given as follows:*

$$\frac{\partial e'}{\partial z} > 0 \tag{6}$$

$$\frac{\partial l}{\partial z} \gtrless 0 \quad \textit{according to} \quad \frac{w'\epsilon' l'^2}{\tau} \gtrless -\frac{u''(c')c' + u'(c')}{u''(c')} \tag{7}$$

$$\frac{\partial l'}{\partial z} \geq \frac{\partial l}{\partial z}, \quad \textit{with strict inequality when} \quad \frac{-u''(c) \cdot c}{u'(c)} < 1. \tag{8}$$

Proof. See Appendix A. ■

[9] In the case of CES preferences with $u(c) = \frac{c^{1-\rho}}{1-\rho}$, this assumption requires that $\rho \leq 1$, implying an elasticity of substitution greater or equal to one.

The first result shows that human capital investment is increasing in the level of household technology, $\frac{\partial e'}{\partial z} > 0$. In particular, the relationship is captured by the following expression:

$$\frac{\partial e'}{\partial T(z)} = \underbrace{\frac{u''(c)\cdot w^2(1+\epsilon e)^2\tau}{u''(c)\,w^2(1+\epsilon e)^2\tau^2 + \beta u''(c')\,w'^2\epsilon'^2 l'^2}}_{\substack{>0.\ \text{Effect on } e' \text{ due to the expansion in} \\ \text{the mother's time endowment } (\uparrow T).}} + \underbrace{\frac{-\beta\left[u''(c')\cdot c' + u'(c')\right]\cdot w'\epsilon'}{u''(c)\,w^2(1+\epsilon e)^2\tau^2 + \beta u''(c')\,w'^2\epsilon'^2 l'^2}}_{\substack{\geq 0.\ \text{Effect on } e' \text{ due to the expansion in the} \\ \text{daughter's time endowment } (\uparrow T').}} \tag{9}$$

The positive relationship between household technology and child investment is a result of two distinct forces. The first term captures the response of human capital investment to an expansion in the mother's time endowment, T. Forward-looking parents will allocate some of this time savings to increased human capital investments, in order to raise the welfare of subsequent cohorts. The second term captures the response of parental investments to the expansion in the daughter's time endowment, T'. When preferences display a sufficient degree of intertemporal substituteability this term is also positive, as parents will forgo current consumption in order to raise the consumption of future cohorts.

The second result shows that the relationship between household technology and mothers' employment is ambiguous, and depends on the responsiveness of parental investment to household modernization. When Assumption 2 holds with equality, it can be shown that employment is strictly *increasing* with the level of household technology.[10] Intuitively, when investment decisions are not influenced by future time endowments – e.g. the second term in equation (9) is equal to zero – mothers will always choose to allocate some of the time savings to employment. On the other hand, when the investment response is large ($\frac{\partial e'}{\partial T} > \frac{1}{\tau}$), employment will decline with household modernization. This situation can only arise when child investment is affected by the future time endowment.

The final result establishes that household technology has a larger impact on second-

[10]This result follows immediately from the fact that $\frac{-u''(c)\cdot c}{u'(c)} = 1$ implies $-\frac{u''(c')c'+u'(c')}{u''(c')} = 0$. Given that $\frac{w'\epsilon' l'^2}{\tau} > 0$, equation (3.7) ensures $\frac{\partial l}{\partial z} > 0$.

generation employment. Differentiating $l'(e'(e,T),T)$ with respect to T yields

$$\frac{\partial l'}{\partial T} = \frac{\partial l'}{\partial e'} \cdot \frac{\partial e'}{\partial T} + \frac{\partial l'}{\partial T}.$$

The second term captures the direct effect of the daughter's own time endowment on her employment. Holding other parameters constant, this term is identical to the first-generation employment response, $\frac{\partial l}{\partial T}$. The first term captures the indirect effect of household technology on employment due to changes in human capital attainment. This term is non-negative, since human capital investment is increasing in the level of household technology, and employment is non-decreasing in human capital, with strict inequality whenever Assumption 2 holds with strict inequality. Since the second-generation cohort obtains greater levels of human capital, thereby raising the return to employment, they will spend more time in paid work.[11]

Taken together, these results provide several predictions for the response of employment and human capital attainment to household technological change. The model predicts a limited employment response among the first generation of women to acquire modern household technologies. Household modernization should also generate a rise in human capital investment in daughters relative to sons – who were already anticipated to be employed full time. The increased human capital investments associated with household modernization should ultimately lead to a rise in employment and income for subsequent cohorts of women, but have limited effect on the employment outcomes of men.[12]

[11]The first term is zero for the first-generation of women to acquire modern household technology, since their human capital was acquired prior to modernization. Even if families fully anticipate the changes to household technology, the investment response is still limited by the fact that the mothers of the first-generation do not have access to labour-saving technologies, so had less time available for child investment.

[12]Since there may be spillovers in child investment, the long-term effect of household modernization on male employment outcomes need not be zero.

4 Empirical strategy

4.1 The short-run effects of household electrification

The first objective of the empirical analysis is to identify the immediate impact of improvements in household technology on female employment and child investments. The estimation strategy exploits wide geographic differences in when families first acquired modern household technology. I adopt a panel estimation strategy, relating changes in the proportion of homes with electricity to contemporaneous changes in female employment and child investments – proxied by school attendance rates.

To examine the effect of household electrification on female employment, I use individual-level data for the years 1940 and 1950 from the Census IPUMS files (Ruggles et al., 2010). These data provide geographic identification at the State Economic Area (SEA) level.[13] The following regression model is estimated:

$$y_{ijrt} = \beta_0 + \beta_1 z_{jrt} + X_{ijrt}\beta_2 + W_{jrt}\beta_3 + \lambda_t + \mu_j + \delta_r\lambda_t + \epsilon_{ijrt}, \tag{10}$$

where y_{ijrt} denotes the employment status of woman, i, in SEA, j, in region, r, in year, t. The dependent variable equals one for women who were employed, and zero otherwise. The term X_{ijrt} is a vector of individual-level controls including age, race, and farm status. The vector W_{jrt} controls for time-varying SEA-level covariates including population, percent urban, literacy, and percent non-white. The regression also controls for SEA and year fixed effects. I include an interaction term between the region and year fixed effects, $\delta_r\lambda_t$, to allow for differential trends in female employment across different parts of the county.

The variable of interest, z_{jrt}, is the proportion of homes in an individual's SEA with electrical services. The estimate β_1 captures the reduced form relationship between household electrification and female employment. The baseline model is estimated separately for women aged 18 to 34 and 35 to 49.

[13] There are roughly 6 counties per SEA.

I next investigate whether the time savings associated household modernization was allocated to investments in children. Ideally, this analysis would relate the diffusion of modern household technologies directly to parental behaviour, for example, as measured by the time devoted to the care of children. Given the limited availability of time-use information for this period, this type of analysis is not feasible. Instead, I focus on the relationship between household modernization and child schooling outcomes. If labour-saving appliances led to increases in human capital investments, it should be reflected in improved educational outcomes. Using county-level data for 1940 and 1950, I analyze the relationship between household electrification and school attendance:

$$y_{crt} = \gamma_0 + \gamma_1 z_{crt} + W_{crt}\gamma_2 + \lambda_t + \mu_c + \delta_r \lambda_t + u_{crt}, \tag{11}$$

where the dependent variable is the proportion of children (age 5-6, 7-13, or 14-17) in county, c, in region, r, in year, t, currently attending school. Because these models are estimated at the county-level, individual-level controls are omitted. Again, the variable of interest, z_{crt}, is the proportion of homes with electricity.

4.2 The long-run effects of household electrification

The second objective of the empirical analysis is to establish whether access to modern household technology during childhood had second generation effects on female employment. I use individual-level data on employment outcomes from the 1980 IPUMS. Restricting the sample to cohorts of women born between 1916 and 1955, I estimate the following regression:

$$y_{isrc} = \beta_0 + \beta_1 z_{src} + X_{isrc}\beta_2 + \lambda_c + \mu_s + \delta_r \lambda_c + \epsilon_{isrc}, \tag{12}$$

where y_{isrc} is the employment status of individual, i, born in state, s, in region r, in cohort, c. The term X_{isrc} is a vector of individual-level controls for race, education level, marital status, and number of children.[14] μ_s and λ_c are fixed effect controls for state and year of birth. The term $\delta_r \lambda_c$ allows for region-specific cohort effects in employment. The variable of interest, z_{src}, is the proportion of homes with electrical services in the woman's state of birth when she was age 5 to 14. This range is chosen to correspond with the period in which parents were most likely to have been making human capital investment decisions for their children. Variation in z_{src} stems from both within-state of birth variation driven by cross-cohort differences in electricity exposure, and within-cohort variation driven by the uneven geographical pattern of electrification.

4.3 The rollout of the U.S. power grid & household electrification

There are several reasons why the estimates in equations (10), (11), and (12) may be biased. First, the decision to supply households with electricity was non-random, since private power companies had an incentive to provide power to wealthy households who were likely to consume more energy (Tobey, 1996). Since household wealth may have influenced both female employment and child investment decisions, the estimates of β_1 and γ_1 could be biased. In addition, household electrification rates may be a poor proxy for the actual state of household technology, in which case, measurement error would lead the estimates to be biased towards zero. To address both these issues, I estimate instrumental variables (IV) regressions, exploiting plausibly exogenous variation in the cost of supply power to different communities.

To construct the instrument, I rely on a set of seven maps produced by the Federal Power Commission in 1962. These maps identify the location of all power plants in the U.S., along with information on ownership (private, federal, state, municipal, or cooperative), capacity (in megawatts), and type of facility (hydroelectric, internal combustion, or steam). Figure 5 presents a section of one of the maps. Each numbered circle or square corresponds to a particular power plant. I use GIS software to digitize these maps, associating each power

[14]Given potential endogeneity, the regressions are estimated with and without the controls for education, marital status, and number of children

plant with a specific location. These data are supplemented with information on the timing of plant openings to construct a decennial panel of power plants from 1930 to 1960.

Between 1930 and 1960, more than 1,000 power plants were built. Figure 6 describes the location of each power plant, by capacity, for decennial years 1930 through 1960. In 1930, there had already been substantial development of the power industry throughout the northeast and in California, although few plants had been built in the midwest or south. Over the next 30 years there was dramatic growth in both the number of power plants and the average capacity. Plants continued to be built along the west coast and throughout the northeast, and there was significant development throughout the south and midwest. By 1960, there was wide coverage throughout the country.

I use this data to estimate instrumental variables (IV) regressions, exploiting plausibly exogenous variation in the cost of supply power to different communities. I rely on the fact that it was less costly to provide electricity to communities located near a power plant, and use county-centroid distance to the nearest power plant, $distance_{crt}$, as an instrument for household electrification.[15]

Two assumptions should hold for this identification strategy to be valid. First, county distance to power plants must be a strong predictor of household electrification. This assumption is supported by historical evidence on power transmission. Since power companies were responsible for the construction and maintenance costs of transmission lines, they had an incentive to supply power locally (Lovell, 1941). This incentive was magnified by voltage limitations, which constrained the distance electricity could be shipped.

The second assumption requires that changes in county distance to power plants was uncorrelated with unobservable determinants of female employment and child investment. This assumption includes 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 was made independent of unobservable determinants of these child

[15]The SEA-level instrument, $distance_{jrt}$, is constructed as a population weighted average of the county-level instrument.

outcomes. 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 the determinants of power plant location. The two dominant sources of power generation were hydroelectricity and steam, which accounted for 98% of electricity generation in 1960 (Federal Power Commission, 1962). Both steam and hydroelectric plants had long lifespans: steam plants lasted from 30 to 50 years, and hydroelectric plants from 50 to 100 years (International Energy Agency, 2010). Given the longevity of these facilities, decisions about where to build plants were primarily made on the basis of long-term local demand for power, rather than transitory fluctuations. Since the regressions include controls for county fixed effects, time-invariant local characteristics can influence decisions about where to build a power plant without biasing the estimates. Companies also faced severe constraints on where plants could be built, and topographic features were the dominant factor in plant location (Lovell, 1941; Rushmore and Lof, 1923).[16]

The identification strategy also requires that proximity to power plants influenced the dependent variable solely through changes in household technology. There are two primary concerns about this exclusion restriction. First, electrification may have influenced the local demand for female labour. To examine the impact of electrification on the demand for labour, I study the relationship between power plant construction and a range of economic outcomes for males including employment rates, industry composition, and farm productivity. Second, local electrification may have been related to local infrastructure investment, such as schools and roads. If so, the results for school attendance and long-run employment outcomes may simply reflect improvements in school quality or school access. To examine this issue, I study the long-term impact of electrification on males, who should have also benefited from public infrastructure improvements.

[16]Hydroelectric plants were ideally located at a narrow point along a river that had consistent water flow throughout the year, and a sufficient gradient. Steam plants needed to locate near a rail line or coal mine, where there was also a sufficient water supply.

5 Data

5.1 The short-run effects of household electrification

To investigate the impact of household electrification on child investment, I use county-level data for the years 1940 and 1950. The dependent variable is the proportion of children (aged 5-6, 7-13, and 14-17) currently attending school. Information on electrical services are available from the census. For each county, the level of household technology is proxied by the proportion of households with electric lights. These data are supplemented by a rich set of county-level information on economic and demographic covariates (Haines, 2004).

I use data from the Integrated Public Use Microdata Series (IPUMS) to estimate the contemporaneous effect of household electrification on female labour force participation. The IPUMS provides data on individuals and household at the State Economic Area (SEA)-level.[17] The dependent variable is equal to one if a woman is employed and zero otherwise. Household technology is proxied by proportion of homes in an individual's SEA with electrical services. The SEA-level instrument is constructed as a population-weighted average of the county-level instrument: $SEAdistance_{srt} = \sum_{c \in s} distance_{crt} \cdot popfrac_{cs}^{1940}$, where the term $popfrac_{cs}^{1930}$ is the fraction of the SEA population that resided in county c in 1940.

Table 1 reports the sample means for the short-run outcomes. Column (1) reports the the means of employment status for women aged 18-34 and 35-49. Employment rates were higher for younger women – 33% compared to 27%. This gap likely reflects the rise in employment of women, rather than life-cycle patterns in employment, given that participation rates peaked around age 45 (Bailey, 2006). Rows 3-5 report school attendance for children age 5-6, 7-13, and 14-17. Attendance rates were only 36% for younger children, rose to 95% for ages 7 to 13, and declined to 80% for those of high school age. Column (2) reports the proportion of homes with electricity and county-distance to the nearest power plant. Roughly 70% of household had electricity, and the average county was about 40 miles from a power plant.

[17] There are roughly six counties per SEA.

5.2 The long-run effects of household electrification

To estimate the long-run effects of household electrification in equation (12), I use individual-level data from the 1980 IPUMS for cohorts born between 1916 and 1955. This analysis requires information on access to electricity during childhood. State-level data on proportion of households with electrical services is available from the Edison Electric Institute's *Statistical Bulletin* (EEI) for the period 1930 to 1960. I merge this data with individual information on state- and year-of-birth to construct the variable, z_{src}, the proportion of homes with electrical services in an individual's state-of-birth when she was between ages 5 and 14. The state-level instrument – average state distance to power plants – is constructed in the same manner as the SEA-level instrument.[18] The outcomes of interest are employment status, the logarithm of personal income, and usual weekly hours worked. I also explore the second generation effects on marital status, fertility, and completed education – measured by education level (12 categories), and a dummy variable for high school graduation.

Table 2 reports the summary statistics for these variables. More than 55% of females and 85% of males were employed. Usual weekly hours of work was 22.5 for women and 39 for men. The gender gap in work hours was not solely driven by differences in employment rates. Conditional on employment, men worked an average of 43 hours per week compared to 35.5 for women. For these cohorts, mean childhood access to electrical services was 83%.

6 Results

6.1 The first-stage relationship

Before proceeding to the main results, I first confirm that distance to power plants has strong predictive power for household electrification. Table 3 reports the first-stage results for the county-level regressions. The first row reports the estimates using the primary instru-

[18]Specifically, $statedistance_{srt} = \sum_{c \in s} distance_{crt} \cdot popfrac_{cs}^{1930}$, where the term $popfrac_{cs}^{1930}$ is the fraction of the state population that resided in county c in 1930.

ment, $distance_{crt}$. Across a variety of specifications, there is a strong relationship between distance to the nearest power plant and the proportion of homes with electric lights. In the preferred specification, a one standard deviation (40 mile) decrease in county distance to the nearest power plant is associated with a 2 percentage point increase in electrification rates and stove ownership that is highly significant.

In the second row of Table 3, I examine the functional form of the first-stage relationship. I re-estimate the county-level first-stage regressions non-parametrically with a vector of distance dummy variables. In the preferred specification, the construction of a power plant within 40 miles of a county raises household electrification rates by 5 percentage points relative to county at least 60 miles from a power plant. The first-stage relationship weakens with distance, and the estimates are insignificant for counties more than 60 miles from a power plant. Given that technological limitations restricted long-distance transmission, the first-stage relationship should not be expected to hold at long distances.

In the last two rows of Tables 3, I report two alternative specifications of the first-stage regression. First, I re-estimate the baseline model including small (<10 mw capacity) power plants and internal combustion plants in the construction of the instrument, $distance_{crt}$. These power plants were initially excluded, given the potential endogeneity in location. The inclusion of these additional plants raises the magnitude of the point estimates. In the final row, I estimate the first-stage regression using a new instrument: the logarithm of total capacity generating within 50 miles of the county. This instrument combines information on the timing of power plant openings with additional information on power plant capacity.[19] The results from these regressions are qualitatively similar to the baseline specification. For example, a 10% increase in generation capacity was associated with roughly a 13 percentage point rise in the proportion of homes with electric lights.[20]

[19] In the baseline analysis, information on capacity was excluded because of endogeneity concerns. In particular, companies could potentially adjust the capacity at a particular site to meet the electricity demands of the local population.

[20] The first-stage results for the state-level regressions (not reported) are also highly significant.

6.2 Short-run effects of household technological change

6.2.1 Female employment

Table 4 reports estimates for the short-run effect of household electrification on female employment. The regressions are estimated separately for women aged 18-34 and 35-49. The first three columns report the least-squares estimates. In column (1), I include only SEA and year fixed effects; in column (2), I add controls for regional trends; and in column (3), I control for individual- and SEA-level covariates. There is no evidence that improvements in household technology led to an immediate rise in female employment. The estimates imply that a one standard deviation increase in household electrification rates would have raised female employment by at most one percentage point.

Endogeneity in household electrification could bias the least-squares estimates. For example, unobservable increases in wealth may have simultaneously increased the likelihood of modernization and decreased female employment, in which case the OLS results would understate the employment response. To address this concern, columns (4)-(6) report the IV estimates, based on plausibly exogenous access to electrical services driven by the construction of new power plants. Again, there is no evidence labour-saving household technologies induced women to enter the labour market. In the preferred specification, the estimates are negative and statistically insignificant.

The point estimates in Table 4 are slightly more positive (less negative) for younger women. For example, the estimates in column 3 imply that a one standard deviation increase in household electrification led to a 3% rise in employment for women aged 18-34 and a 3% decline in employment for women aged 35-49. These differences may reflect the fact that younger women anticipated the changes in household technology, so were able adjust their human capital stock accordingly. Similarly, younger women may have been better able to adjust family size, reducing the barriers to market work.[21]

Overall, the results in Table 4 confirm that household electrification had virtually no

[21] Lewis (2013) documents the negative relationship between household technological change and fertility.

immediate impact on female employment. The findings support previous research on the relationship between household technology and female labour force participation (see Cardia, 2011), and are consistent with historical evidence that labour-saving appliances did not generate reductions in the amount of time spent in home production (Schwartz Cowan, 1983; Francis and Ramey, 2009).

6.2.2 School attendance

Table 5 reports the estimates for school attendance by age. Household electrification was associated with large increases in school attendance for children aged 5 to 6. The OLS estimates imply that a one standard deviation increase in household electrification would have raised school attendance by 5 percentage points, while the corresponding IV estimates range from 8 to 13 percentage points. There is no evidence of a positive relationship between household technology and school attendance for children aged 7 to 13. This is probably due to the fact that school attendance was already almost universal among this age group. Meanwhile, there is some evidence that household electrification increased in high school attendance. A one standard deviation increase in household electrification is associated with a 1 to 2 percentage point increase in school attendance for children aged 14 to 17, although the IV results are less consistent, and generally insignificant. These results are consistent with household modernization having generated increased investment in child human capital.

Because household modernization reduced the burden of housework for future generations as well, forward looking parents had an incentive to invest in daughters' human capital. If so, household electrification should have led to an increase in the schooling of girls relative to boys, who were already expected to be employed full time. Table 6 reports the estimates of the effect of household electrification on the gender gap in school attendance. In these regressions, the dependent variable is the difference in school attendance rates for each age group. For younger children, there is no evidence that household electrification had any differential effects on school attendance. In both the IV and OLS regressions, the point estimates are generally small and statistically insignificant. For teenagers, there is some evidence that household electrification differentially raised female school attendance. The IV point estimates range from -0.004 to -0.009, and are all statistically significant. These differential effects on female school attendance are consistent with parental investments having been targeted towards teenage daughters. The results may also reflect a decline in the opportunity cost of school participation.

6.3 Long-run effects of household technological change

6.3.1 Female employment, earnings, and hours of work

I now turn to the second generation response to household technological change, examining the relationship between access to electricity during childhood and long-run employment outcomes. Table 7 reports the regression results of β_1 from equation (12). The model is estimated for the full sample of women and separately for married women. The dependent variable is an indicator for employment status.

The first three columns of Table 7 report the least-squares results. Column (1) includes controls for birth cohort and state-of-birth, column (2) adds a control for race, and column (3) adds controls for education, marital status, and number of children. The estimates in column (3) capture the effect of electrification on female employment net of changes in marriage behaviour or educational attainment.[22] Columns (4)-(6) report the corresponding estimates from the IV regressions, where average state distance to power plants is used as an instrument for exposure to electricity.

The results suggest that access to electricity during childhood had a significant effect on future employment. For the full sample, the point estimates range from 0.0009 to 0.0016 and are all highly significant. The estimates predict that a one standard deviation rise in electrification rates would generated a 3.4% to 6.0% increase in future female employment. The findings do not appear to have been driven by increased employment of unmarried

[22]These estimates should be interpreted with caution, since the covariates are themselves endogenous.

women. Among married women, the estimates imply increases in employment ranging from 4.4% to 6.4%. Controlling for marital status, fertility, and educational attainment does not affect the point estimates, which suggests that the effects are not likely to have been caused by changes in schooling or marriage behaviour.

These estimates are large and suggest that household modernization played an important role in the rise in employment of younger cohorts of women. To illustrate, compare the cohorts of women born in 1920 and 1955. Labour force participation of the older cohort at age 45 was 54%, and 78% for the younger cohort (Bailey, 2006). During the same period, childhood access to electricity rose by 34 percentage points. According to the preferred estimates in Table 7, out-of-sample calculations suggest that household electrification accounts for $(0.0016 \times 34)/(0.78 - 0.54) = 22.6\%$ of the difference in employment between these cohorts.

Table 8 reports the results for female earnings and hours of work. Access to electricity during childhood has a large positive effect on future earnings. The point estimates are all highly significant ranging from 0.0024 to 0.0041. At the mean, these effects correspond to increases in annual earnings ranging from $450 to $715 (1980 USD). The estimates in row 2 imply that a one standard deviation increase in access to electricity is associated with an increase of 1 to 1.5 hours per week. This result is partly driven by the participation response to electrification. Row 3 reports the effect of electrification on hours of work among women with positive weekly hours.[23] These estimates are positive and statistically significant, implying that a one standard deviation increase in childhood access to electricity is associated with an increase of 0.7 work hours per week. Comparing these results to the estimates for annual earnings, roughly one quarter of the rise in female income can be attributed to increases in weekly hours, while remaining three quarters was caused either by selection into higher paying jobs or increases in the number of weeks worked.[24]

[23]This analysis may be biased due to selection into employment, but, unless the marginal women induced into employment worked *more* hours than those already working, compositional changes due to selection will tend to bias the estimates towards zero.

[24]To calculate the change in annual income caused by the change in hours worked, I make the following

6.3.2 Male employment, earnings, and hours of work

Electrification may have had broad effects on the local economy. Economic growth associated with electrification may have generated improvements in the long-term employment outcomes of children, for example, through increased funding of schools. Similarly, the roll-out of electricity may have been correlated with public infrastructure investment, such as roads, improving access to schools and hospitals. If so, the previous results could reflect the general long-term benefits of local electrification, rather than changes that occurred within the home.

To examine these issues I study the second generation effect of electrification on male employment. Boys and girls should both have benefited from improved economic conditions and public infrastructure investments. Thus, the impact on long-term employment outcomes should have been similar if electrification primarily influenced children through factors external to the home. On the other hand, household modernization raised the return to investment in daughters relative to sons. If the results were primarily driven by changes that occurred within the home, we would expect a differential improvement in long-term female outcomes.[25]

Table 10 reports the second generation effects of electrification on male employment, annual income, and weekly work hours. The first row reports the estimates for employment status. The OLS results are all statistically significant although small in magnitude. In the preferred estimates a one standard deviation increase in household electrification is associated with just a one percentage point increase in future employment rates. Meanwhile, the IV regression estimates are all very small and statistically insignificant. In the second row, a one standard deviation increase in household electrification rates was associated with a 1% to 2% increase in annual income that is marginally significant. The results for weekly hours are

calculation: Δ annual income = Δ weekly hours $\times$ Average hourly wage $\times$ Average weeks per year = $0.7 \times \$5.90 \times 41.8 = \$172.6$.

[25] This is not to say that household electrification should have had no effect on future male economic outcomes. To the extent that there are spillovers in parental investments, sons may also have benefited from greater investments directed towards daughters.

also small, with effects ranging from 0.2 to 0.4 hours. Taken together, the results in Table 10 confirm that the large effects of household electrification on long-run female economic outcomes were driven primarily by factors occurring within the home, rather than broader changes in the local economy.

6.3.3 Mechanisms

Finally, I turn to the mechanisms that drove the long-term improvement in female employment. One explanation is that increased educational attainment associated with modernization improved future labour market opportunities. Alternatively, access to electricity during childhood may have influenced future marital behaviour, which affected the likelihood of employment. For example, cohorts of women who had access to electricity may have chosen to have fewer children as a way to ease entry to the labour market. Similarly, household modernization may have led to a rise in single-headed households, raising the incentive to work.

I investigate these questions in Table 11. The first two rows report the effects of electrification on educational attainment – proxied by education level (12 categories) and a dummy variable for high school graduation. The OLS estimates for education level are small, and the IV estimates are all statistically insignificant. Household electrification also had little effect on high school graduation rates. A one standard deviation increase in electrification is associated with a 1% to 3.5% increase in female graduation rates, that varies in statistical significance. Overall, it does not appear that the increases in school attendance associated with electrification – found in Tables 5 and 6 – translated into increased long-term educational attainment. Thus, the rise in female employment cannot have been due to increases in completed schooling.[26]

The last two rows of Table 11 report the effect of electrification on female marital behaviour. Row 3 reports the results for fertility. Childhood access to electricity is associated

[26] Similarly small effects for were found for male school attainment (not reported).

with an *increase* in fertility. In the preferred specification, a one standard deviation increase in electrification rates is associated with a 4% increase in fertility. Since the presence of children within the home reduces the likelihood of female labour force participation, changes in fertility caused by household electrification cannot be responsible for the rise in female employment. Row 4 reports the second generation effects of household electrification on entry into marriage. The estimates are small and generally insignificant, suggesting that changes in marriage behaviour was not driving the economic gains of women.

Overall, there is little evidence that either changes in educational attainment, fertility, or marriage was responsible for the rise in female employment. One explanation for these findings is that investments in daughters were primarily informal. For example, mothers appear to have taken over many of the childcare duties that had historically been done by teenage daughters (Schwartz Cowan, 1983). These investments may have improved the quality of daughters' schooling without affecting school attainment. Similarly, as daughters revised their expectations over the value of market work relative to home production, they may have selected into careers that were better suited for long-term employment. A third possibility is that the first generation labour market response to modernization was hampered by barriers to entry, such as marriage bars and lack of part-time employment opportunities (Goldin, 2006). As these barriers were eliminated, younger cohorts of women were able to reallocate time to market work.

7 Conclusion

This paper studies how improvements in household technology affect female labour market outcomes. I present a simple conceptual framework in which household technological change permanently reduces the burden of basic housework, expanding the time budget constraint and raising the returns to investment in daughters. Household technological change is predicted to have an ambiguous immediate impact on female employment, but leads to increased investment in daughters, ultimately causing a permanent rise in the employment of future generations of women.

I study these relationships by exploiting large cross-county and cross-state variations in the timing of household electrification between 1930 and 1960. The findings support these predictions. Household electrification had virtually no immediate effect on female employment, but led to increases in school attendance, particularly for teenage daughters. For the second generation of women, childhood access to electricity is associated with large increases in employment and personal income. These results were not caused by local economic development associated with electrification, but were rather due to changes that occurred within the home. The long-run improvements in female economic outcomes were not driven by changes in marriage rates, completed education, or fertility. Instead the results may have been caused by changes in informal parental investments or revised expectations over future employment among younger cohorts of women.

This research contributes to our understanding of the large increases in female labour force participation since 1950. The results suggest that the diffusion of modern technology into the home between 1930 and 1960 played a significant role in the rise in female employment during the the latter half of the century. In fact, household electrification can account for almost one quarter of the cross-cohort differences in employment for women born in 1920 and 1955.

This research also adds to our understanding of the impact of household technological change. The findings help reconcile how modernization substantially reduced the demands of basic housework, but led to little initial change in time spent in home production or employment. Instead, it took several decades for the full impact of these new technologies to be felt. These results have relevance to the developing world, where over 300 million families still do not have access to electricity (World Bank, 2008). In particular, they suggest that an evaluation of the immediate impact of new electrification programs may drastically understate the long-term benefits of electricity infrastructure investments.

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Table 1: Sample means: Short-run variables

Dependent variables		Access to modern technology	
Female employment status, by age		Household modernization	
Age 18-34	0.33	% homes with electric lights	69.6
	[0.47]		[25.0]
Age 35-49	0.27	Distance to nearest power plant	43.1
	[0.44]		[40.2]
School attendance rates, by age			
Age 5-6	36.2		
	[12.3]		
Age 7-13	94.2		
	[7.6]		
Age 14-17	81.2		
	[15.3]		

Notes: The table reports unweighted means across U.S counties and State Economic Areas (SEAs) for the years 1940 and 1950, excluding Hawaii and Alaska. The left-hand-side reports the dependent variables. The first two rows report individual-level data from the IPUMS on female employment status at the SEA-level. The next three rows report the county-level school attendance rates by age. The right-hand-side reports the measures of access to electricity. The first row reports the proportion of homes with electric lights, and the second row reports the mean distance from the county-centroid to the nearest power plant. Standard deviations in parentheses.

Table 2: Sample means: Long-run outcomes

	Panel A: Females		**Panel B:** Males	
Variable	Mean	S.D.	Mean	S.D.
Employment status				
All individuals	0.56	0.50	0.84	0.36
Married individuals	0.52	0.50		
Log(total personal income)	8.58	1.16	9.55	0.87
Usual weekly hours of work				
All individuals	22.5	19.4	39.0	16.4
If hours >0	35.5	11.4	43.3	10.6
Education				
Level (12 categories)	6.22	2.42	6.55	2.77
High school graduate	0.74	0.43	0.74	0.44
Number of children	1.24	1.35		
Married	0.72	0.45		
% lights (at age 5-14)	83.4	20.9	83.4	20.9
Average distance to power plant (at age 5-14)	23.6	19.7	23.6	19.7

Notes: The table reports individual-level sample means in 1980 for cohorts born between 1916 and 1955, excluding cohorts born in Hawaii and Alaska. The first two rows report a dummy variable for employment status. The second-last row reports the average exposure to electricity when aged 5-14, based on state of birth. The last row reports the average distance to a power plant when aged 5-14, based on state of birth. Standard deviations in parentheses.

Table 3: First-stage results – Distance to power plants and % homes with electricity

Dependent variable: % homes with electric lights			
	(1)	(2)	(3)
Independent variable:			
Distance to nearest power plant	-0.0905***	-0.0731***	-0.0528***
	[0.0125]	[0.0124]	[0.00930]
Independent variable:			
Vector of distance dummies			
I(D< 10 miles)	5.426**	6.775***	2.417
	[2.127]	[1.974]	[1.555]
I(10 < D < 20 miles)	11.54***	8.786***	4.550***
	[1.593]	[1.489]	[1.244]
I(20 < D < 30 miles)	13.43***	9.631***	5.507***
	[1.351]	[1.287]	[1.052]
I(30 < D < 40 miles)	10.71***	8.291***	4.507***
	[1.305]	[1.274]	[1.039]
I(40 < D < 50 miles)	8.230***	6.124***	3.092***
	[1.302]	[1.233]	[1.016]
I(50 < D < 60 miles)	5.312***	4.399***	2.824***
	[1.331]	[1.268]	[1.028]
Independent variable:			
Distance to nearest power plant	-0.258***	-0.178***	-0.100***
(including small plants & I.C. plants)	[0.0303]	[0.0309]	[0.0237]
Independent variable:			
Log capacity generated within 50 miles	4.208***	3.458***	1.334***
	[0.520]	[0.492]	[0.414]
Demographics	N	Y	Y
County & Year FE	Y	Y	Y
Region×year	N	N	Y
Observations	6170	6170	6170

Notes: The dependent variable is the percent of households with electric lights. The first row reports the original first-stage estimates for $distance_{crt}$. The next rows report the estimates on a set of 6 distance dummies. The second last row includes small (<10mw) power plants and internal combustion power plants when calculating $distance_{crt}$. The final row reports the estimates on based on the log capacity generated within 50 miles of the county-centroid. Standard errors are clustered at the county-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 4: First-stage results – Distance to power plants and % homes with electricity (state-level results)

Dependent variable: % homes with electric lights

	(1)	(2)	(3)
Average state distance to power plant	-0.240***	-0.188***	-0.120***
	[0.0475]	[0.0376]	[0.0306]
Demographics	N	N	Y
Year & State FE	Y	Y	Y
Region×year	N	Y	Y
Observations	192	192	192
R-squared	0.77	0.90	0.93
F-test (instrument)	25.0	25.0	19.3

Notes: The table reports the estimates on $statedistance_{srt}$ from the first-stage regression. Each cell reports the point estimate from a different regression. The dependent variable is the proportion of homes with electricity. Demographic covariates include percent non-white, percent urban, log population, log density, percent employed in agriculture and manufacturing, median home value, median schooling, log farm value, and the maternal mortality rate. Standard errors are clustered at the state-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 5: The effect of household electrification on female employment, by age

Dependent variable: Employment status

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Sample: Females, age 18-34						
Percent lights	0.0004**	0.0005*	0.0004	0.0000	-0.0002	-0.0008
	[0.0002]	[0.0003]	[0.0003]	[0.0005]	[0.0009]	[0.0013]
Sample: Females, age 35-49						
Percent lights	-0.0001	0.0003	-0.0004	-0.0012**	-0.0016*	-0.0020
	[0.0003]	[0.0002]	[0.0004]	[0.0005]	[0.0009]	[0.0015]
Demographic controls	N	N	Y	N	N	Y
SEA & Year FE	Y	Y	Y	Y	Y	Y
Region×year	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 6: The effect of electrification on school attendance rates, by age

Dependent variable: School attendance rate ((fraction attending school)×100)

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Sample: Ages 5-6						
Percent lights	0.385***	0.393***	0.239***	0.349***	0.339***	0.489***
	[0.022]	[0.026]	[0.029]	[0.095]	[0.116]	[0.155]
Sample: Ages 7-13						
Percent lights	0.149***	0.145***	0.029	0.119*	0.115	-0.045
	[0.015]	[0.018]	[0.020]	[0.067]	[0.083]	[0.107]
Sample: Ages 14-17						
Percent lights	0.129***	0.106***	0.059***	0.118**	0.094	0.020
	[0.013]	[0.014]	[0.018]	[0.051]	[0.063]	[0.086]
Demographics	N	Y	Y	N	Y	Y
Year & County FE	Y	Y	Y	Y	Y	Y
Region×year	N	N	Y	N	N	Y
Observations	6170	6170	6170	6170	6170	6170

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). Demographic covariates include percent non-white, percent urban, log population, log density, percent employed in agriculture and manufacturing, median home value, median schooling, and log farm value. Standard errors are clustered at the county-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 7: The effect of electrification on gender differences in school attendance

Dependent variable: Gender gap in school attendance rate (Male − female)

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Sample: Ages 5-6						
Percent lights	0.196	0.261	0.236	0.125	0.245	0.102
	[0.131]	[0.172]	[0.203]	[0.243]	[0.460]	[0.535]
Sample: Ages 7-13						
Percent lights	0.013	0.001	0.021	0.024	0.000	-0.022
	[0.035]	[0.043]	[0.051]	[0.077]	[0.136]	[0.153]
Sample: Ages 14-17						
Percent lights	0.089	0.049	-0.020	-0.422**	-0.824*	-0.866**
	[0.089]	[0.112]	[0.137]	[0.207]	[0.431]	[0.417]
Demographics	N	Y	Y	N	Y	Y
Year & SEA FE	Y	Y	Y	Y	Y	Y
Region×year	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 school attendance rate (male - female). Standard errors are clustered at the SEA-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 8: Long-run effects of electrification on female employment

	Dependent variable: Employment status					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Sample: All women						
% lights (at age 5-14)	0.001	0.0009	0.0009	0.0015	0.0015	0.0016
	[0.0002]***	[0.0002]***	[0.0002]***	[0.0005]***	[0.0005]***	[0.0005]***
Observations	249693	249693	249693	249693	249693	249693
Sample: Married women						
% lights (at age 5-14)	0.0011	0.0011	0.0011	0.0015	0.0015	0.0016
	[0.0003]***	[0.0003]***	[0.0003]***	[0.0006]**	[0.0006]**	[0.0006]***
Observations	179652	179652	179652	179652	179652	179652
Cohort & birthstate FE	Y	Y	Y	Y	Y	Y
Race	N	Y	Y	N	Y	Y
Birth state trend	N	Y	Y	N	Y	Y
Other covariates	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 regressions are estimated for cohorts born between 1916 and 1955 in the 1980 IPUMS data. The dependent variable is an indicator for employment status. 'Other covariates' include education level, marital status, and number of children. Standard errors are clustered at the state-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 9: Long-run effects of electrification on female income and hours worked

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent: Log(personal income)						
% lights (at age 5-14)	0.0024	0.0024	0.0026	0.0033	0.0033	0.0041
	[0.0005]***	[0.0005]***	[0.0005]***	[0.0014]**	[0.0014]**	[0.0013]***
Observations	187310	187310	187310	187310	187310	187310
Dependent: Weekly hours						
% lights (at age 5-14)	0.0483	0.0482	0.0498	0.0666	0.0667	0.0733
	[0.0089]***	[0.0089]***	[0.0088]***	[0.0200]***	[0.0200]***	[0.0193]***
Observations	249693	249693	249693	249693	249693	249693
Dependent: Weekly hours (if >0)						
% lights (at age 5-14)	0.0098	0.0098	0.0148	0.0254	0.0254	0.0315
	[0.0059]*	[0.0059]*	[0.0057]**	[0.0145]*	[0.0145]*	[0.0143]**
Observations	157888	157888	157888	157888	157888	157888
Cohort & birthstate FE	Y	Y	Y	Y	Y	Y
Race	N	Y	Y	N	Y	Y
Birth state trend	N	Y	Y	N	Y	Y
Other covariates	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 regressions are estimated for cohorts born between 1916 and 1955 in the 1980 IPUMS data. The dependent variables are the logarithm of person income, usual weekly hours worked, and usual weekly hours worked if positive. 'Other covariates' include education level, marital status, and number of children. Standard errors are clustered at the state-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 10: Long-run effects of electrification on male employment, income, and hours worked

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent: Employment status						
% lights (at age 5-14)	0.0006	0.0006	0.0005	0.0002	0.0003	0.0000
	[0.0002]***	[0.0002]***	[0.0002]**	[0.0004]	[0.0004]	[0.0004]
Observations	236389	236389	236389	236389	236389	236389
Dependent: Log(personal income)						
% lights (at age 5-14)	0.0009	0.001	0.0006	0.0017	0.0017	0.0011
	[0.0004]**	[0.0003]***	[0.0003]**	[0.0009]*	[0.0009]*	[0.0009]
Observations	230238	230238	230238	230238	230238	230238
Dependent: Weekly hours						
% lights (at age 5-14)	0.0274	0.0285	0.021	0.0184	0.0185	0.009
	[0.0080]***	[0.0072]***	[0.0074]***	[0.0173]	[0.0171]	[0.0167]
Observations	236389	236389	236389	236389	236389	236389
Dependent: Weekly hours (if >0)						
% lights (at age 5-14)	0.0009	0.0021	0.0001	-0.0093	-0.0088	-0.0114
	[0.0044]	[0.0042]	[0.0041]	[0.0120]	[0.0119]	[0.0119]
Observations	212988	212988	212988	212988	212988	212988
Cohort & birthstate FE	Y	Y	Y	Y	Y	Y
Race	N	Y	Y	N	Y	Y
Birth state trend	N	Y	Y	N	Y	Y
Other covariates	N	N	Y	N	N	Y

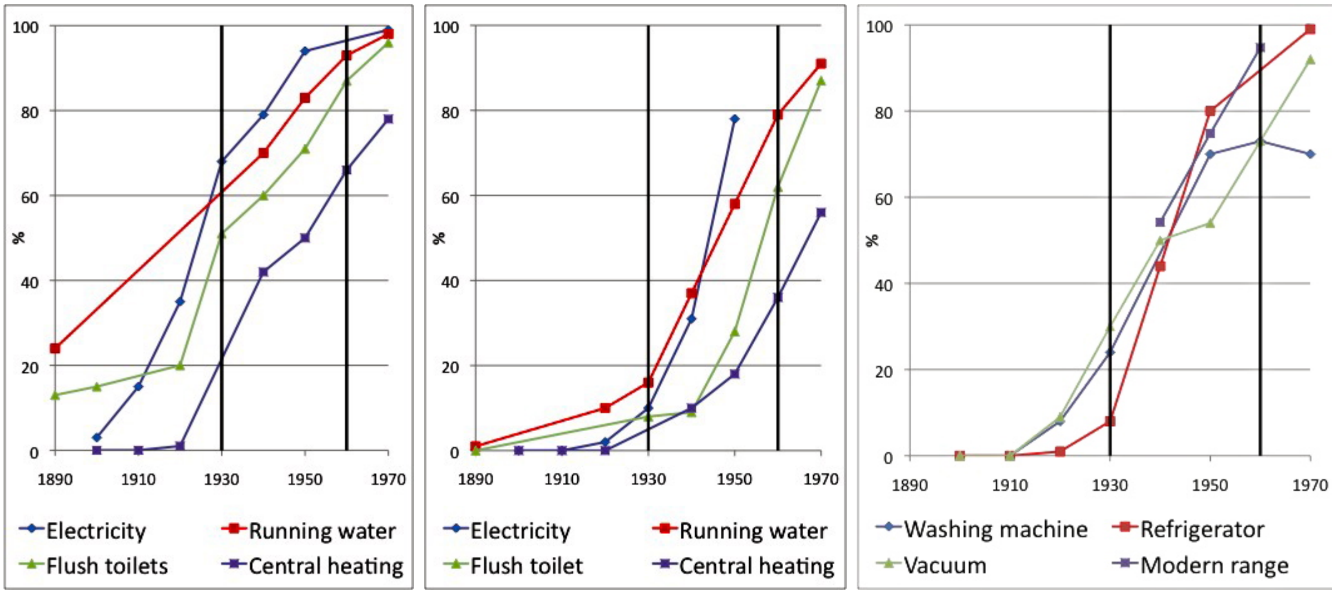
Notes: The table reports the estimates of household technology from OLS and IV regressions. Each cell reports the point estimate from a different regression. The regressions are estimated for cohorts born between 1916 and 1955 in the 1980 IPUMS data. The dependent variables are employment status, the logarithm of person income, usual weekly hours worked, and usual weekly hours worked if positive. 'Other covariates' include education level, marital status, and number of children. Standard errors are clustered at the state-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

Table 11: Long-run effects of electrification on female schooling, fertility, & marriage

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent: Education level						
% lights (at age 5-14)	0.0034	0.0035	0.0035	-0.0017	-0.0017	-0.0017
	[0.0009]***	[0.0009]***	[0.0009]***	[0.0024]	[0.0024]	[0.0024]
Dependent: High school graduate						
% lights (at age 5-14)	0.0018	0.0018	0.0018	0.0005	0.0005	0.0005
	[0.0002]***	[0.0003]***	[0.0003]***	[0.0004]	[0.0004]	[0.0004]
Dependent: Number of children						
% lights (at age 5-14)	0.0026	0.0025	0.0025	0.0022	0.0022	0.0022
	[0.0009]***	[0.0009]***	[0.0009]***	[0.0013]*	[0.0013]*	[0.0013]*
Dependent: Married						
% lights (at age 5-14)	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
	[0.0002]*	[0.0001]**	[0.0001]**	[0.0005]	[0.0005]	[0.0005]
Cohort & birthstate FE	Y	Y	Y	Y	Y	Y
Race	N	Y	Y	N	Y	Y
Birth state trend	N	N	Y	N	N	Y
Observations	249693	249693	249693	249693	249693	249693

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 regressions are estimated for cohorts born between 1916 and 1955 in the 1980 IPUMS data. The dependent variables are education level (12 categories), an indicator for high school graduation, number of children, and an indicator for married. Standard errors are clustered at the state-level. ***,**,* denote significance at the 1%, 5%, and 10% level, respectively.

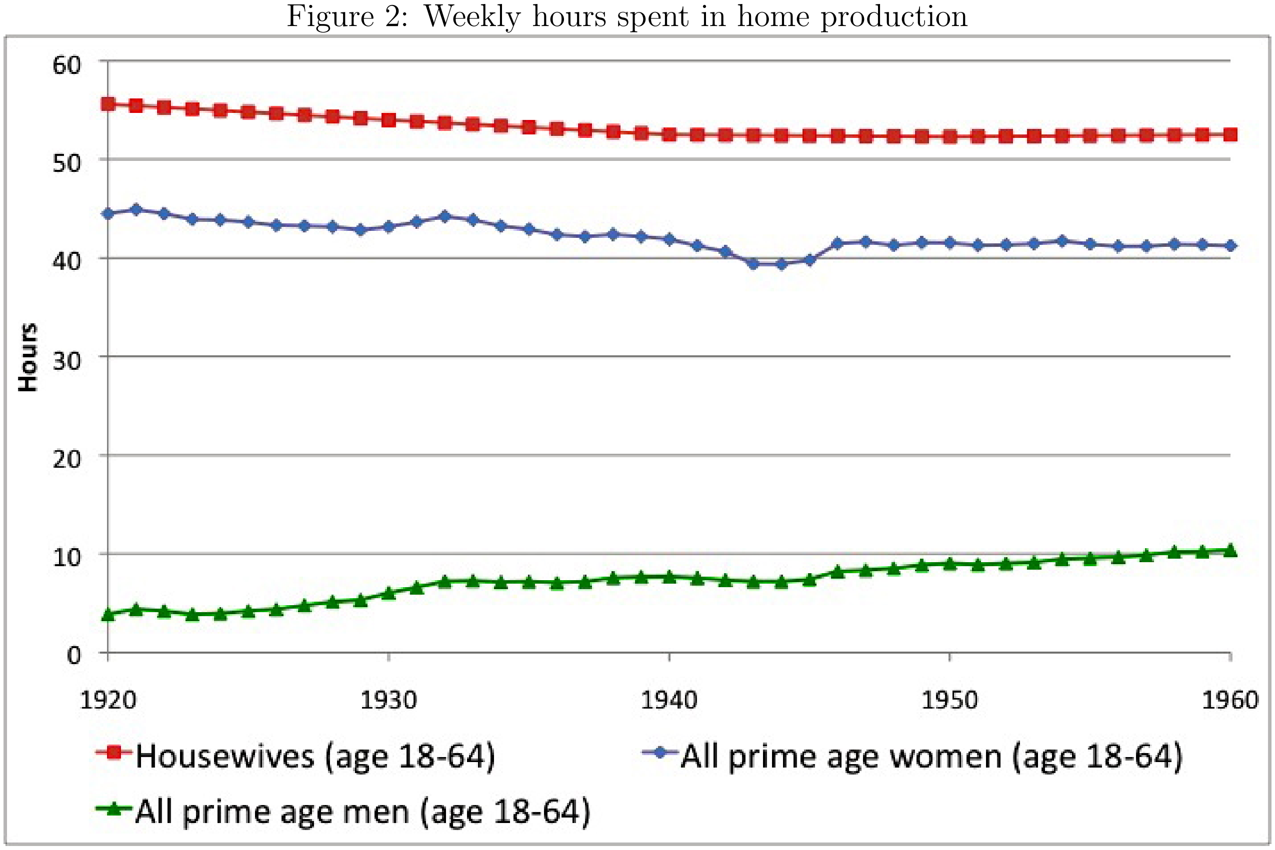
Figure 1: The diffusion of basic facilities and modern appliances



(a) Basic facilities (b) Basic facilities (rural) (c) Modern appliances

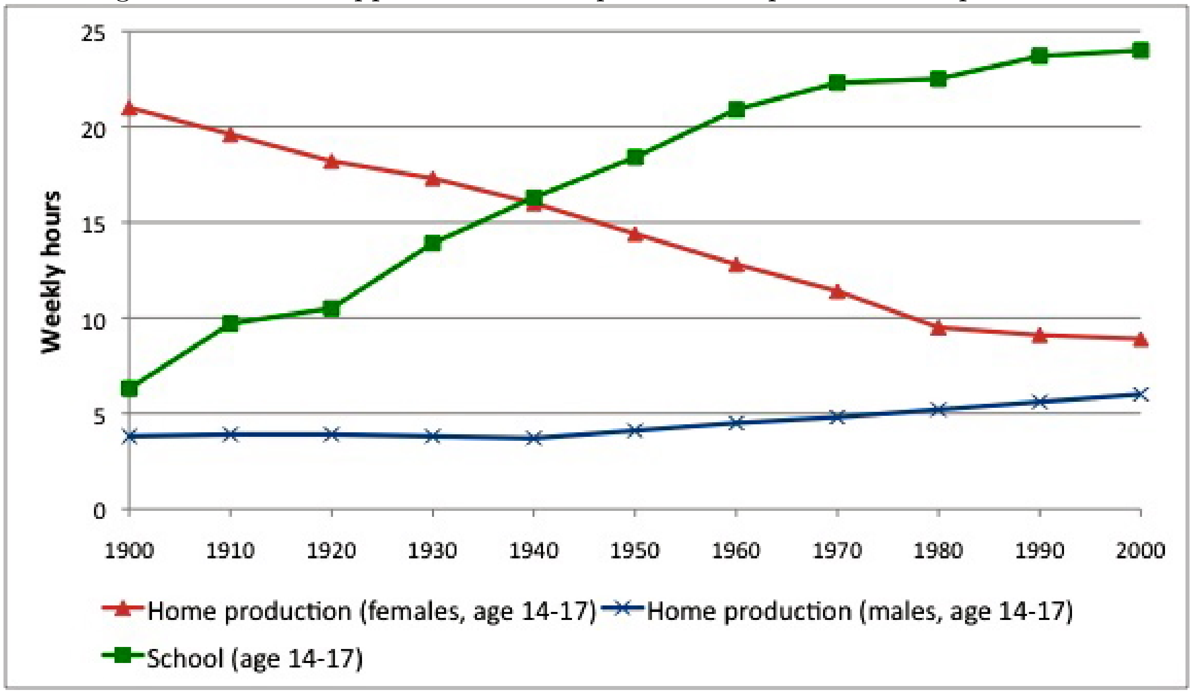
Note: This figure reports the proportion of homes owning various basic facilities and modern appliances. I interpolate between missing values. Source: Lebergott (1976); 1940, 1950, 1960 Census of Housing.

Figure 2: Weekly hours spent in home production



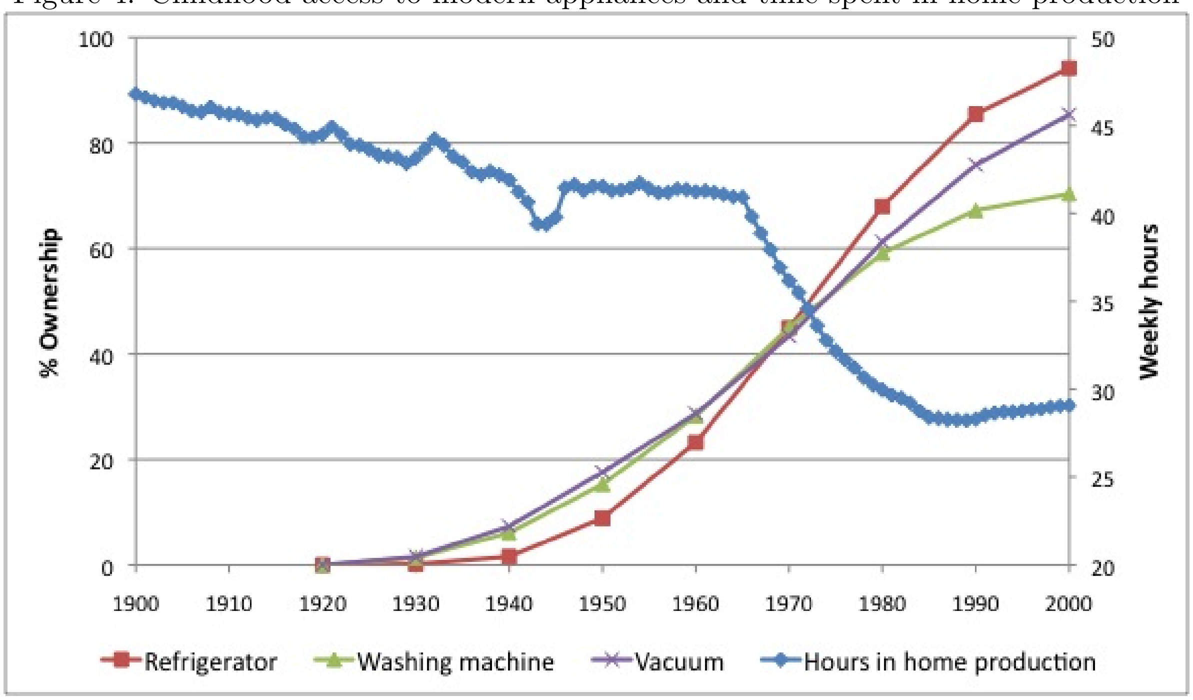
Note: This figure reports the weekly hours spent in home production for housewives, prime age women, and prime age men. Source: Ramey (2009).

Figure 3: Modern appliance ownership and time spent in home production



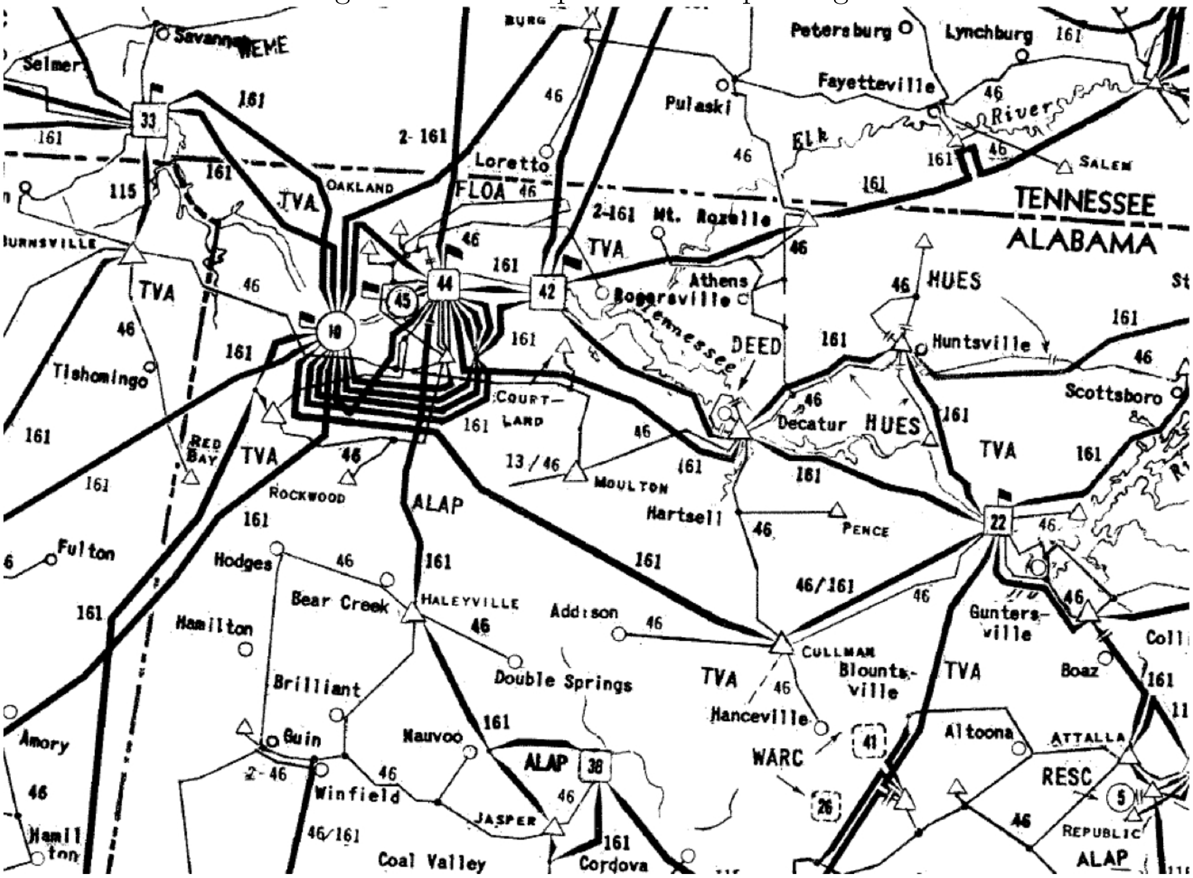
Note: This figure reports the proportion of homes with various modern appliances, and weekly hours spent in home production for women aged 18-64. Sources: Lebergott (1976), U.S. Census of Housing (1940, 1950, 1960), Ramey (2009).

Figure 4: Childhood access to modern appliances and time spent in home production



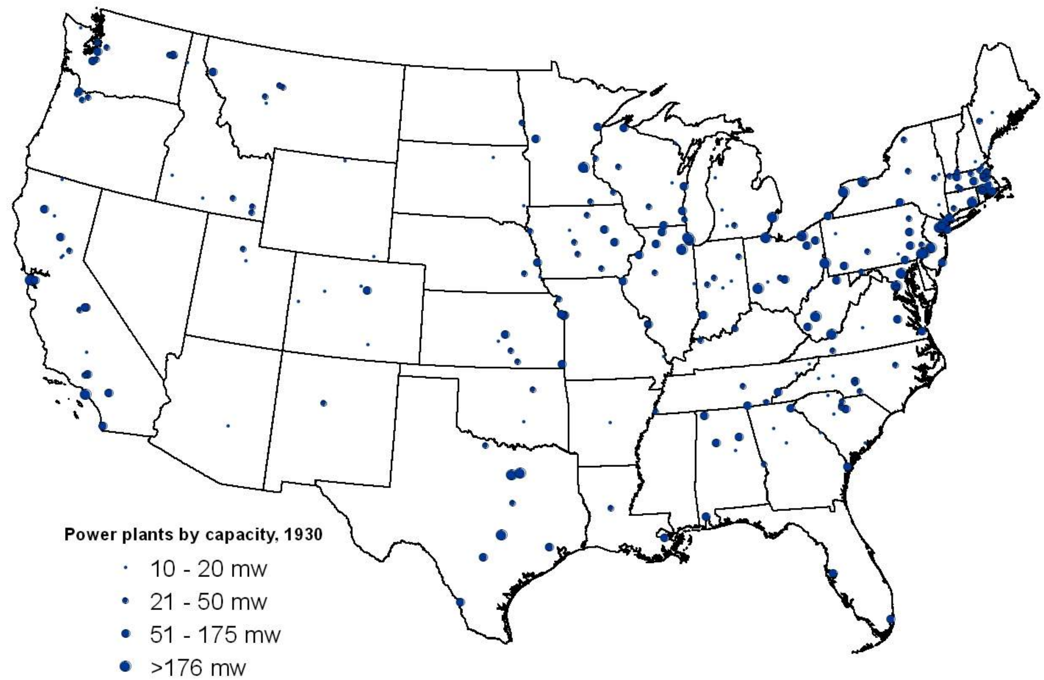
Note: This figure reports childhood access to various modern appliances, and weekly hours spent in home production for women aged 18-64. The measure of childhood access is constructed as the proportion of adult women (aged 18-64) who resided in a home with each modern appliance at the age of 10. Sources: Lebergott (1976), U.S. Census of Housing (1940, 1950, 1960), Ramey (2009).

Figure 5: 1962 map of the U.S. power grid

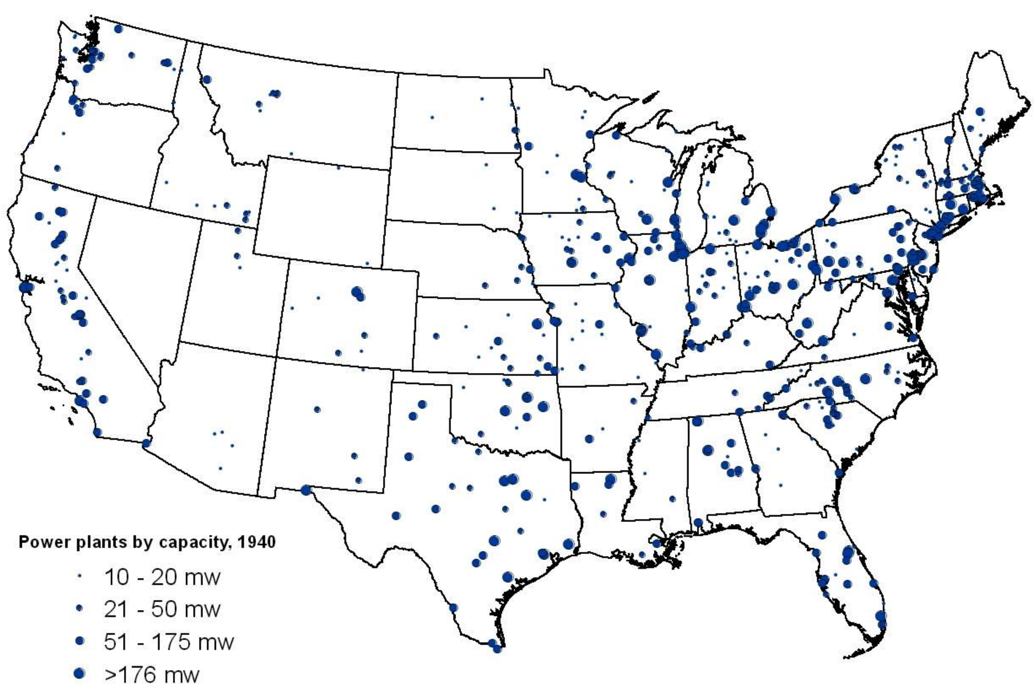


Note: Each numbered circle and square identifies the location of a power plant. Source: U.S. Federal Power Commission (1963)

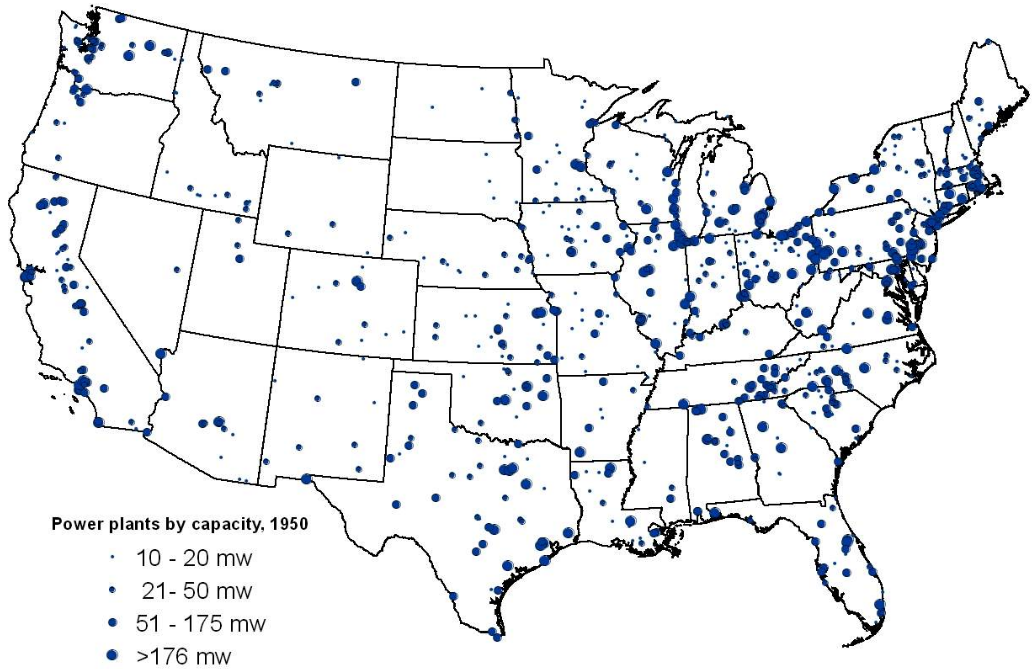
Figure 6: U.S. power plants, 1930-1960



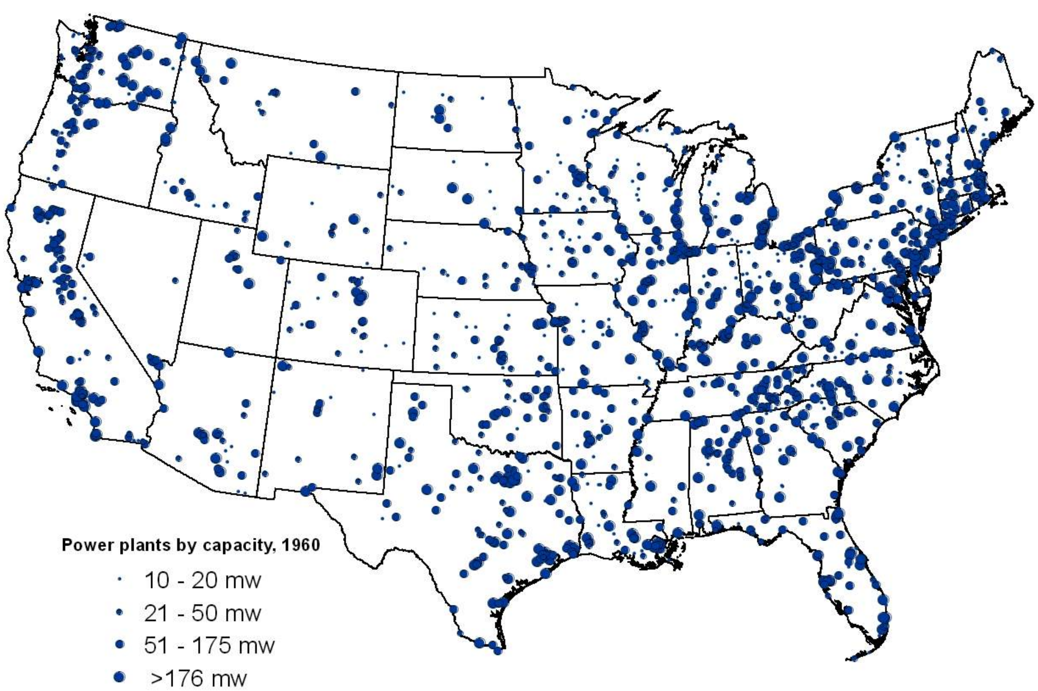
(a) 1930



(b) 1940

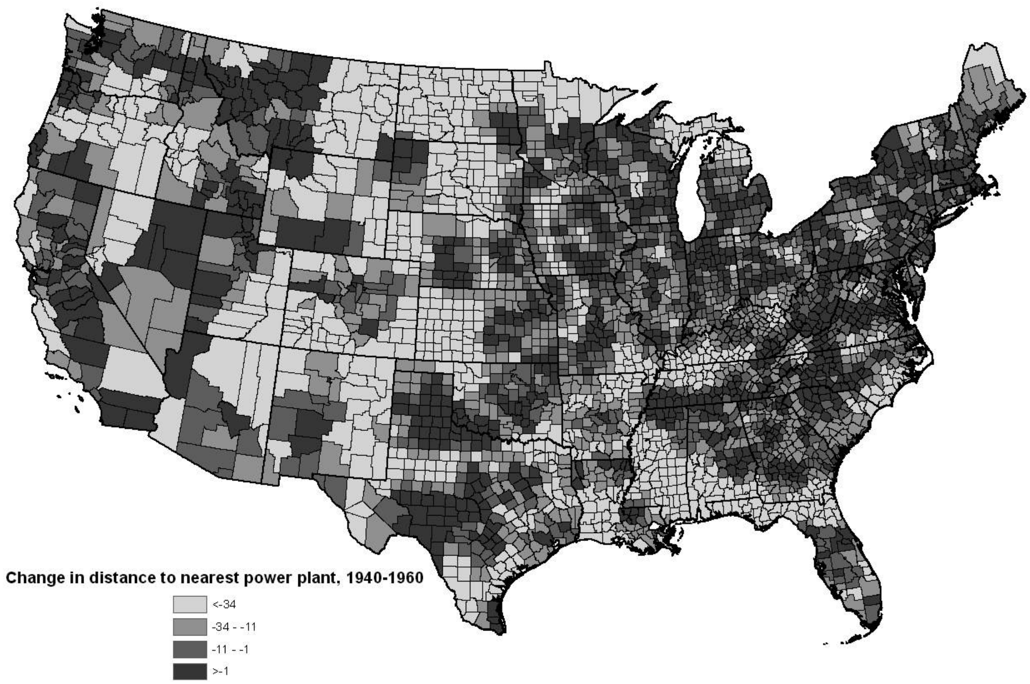

Power plants by capacity, 1950
10 - 20 mw
21- 50 mw
51 - 175 mw
>176 mw

(c) 1950

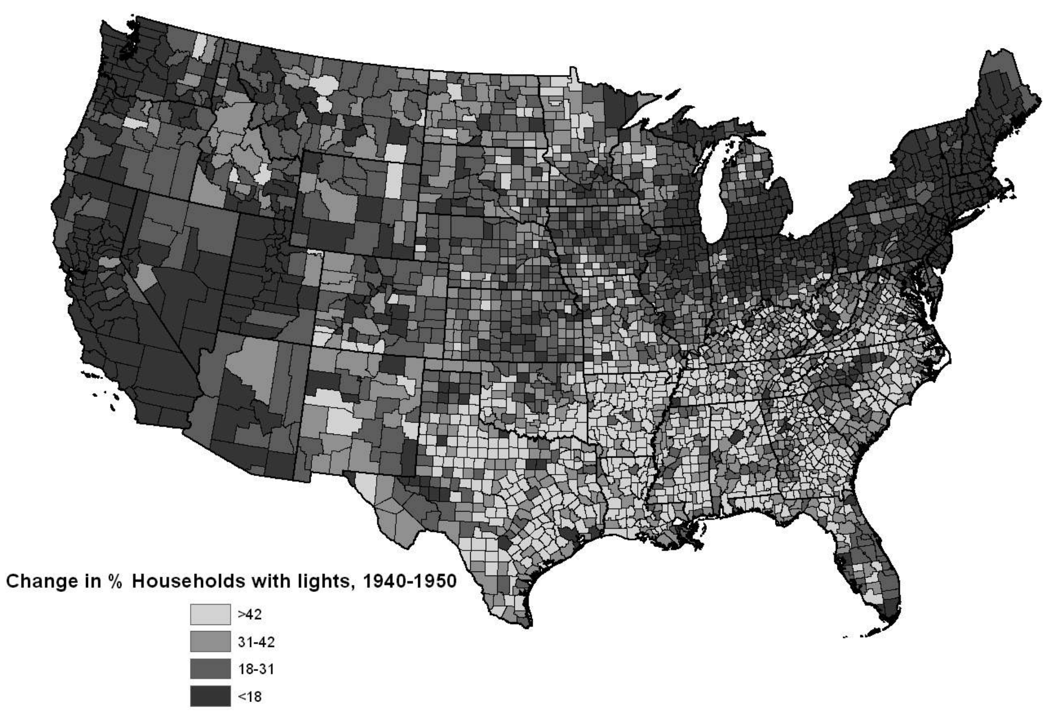

Power plants by capacity, 1960
10 - 20 mw
21 - 50 mw
51 - 175 mw
>176 mw

(d) 1960

Figure 7: Distance to power plants, household electrification, and appliance ownership: 1940-1960

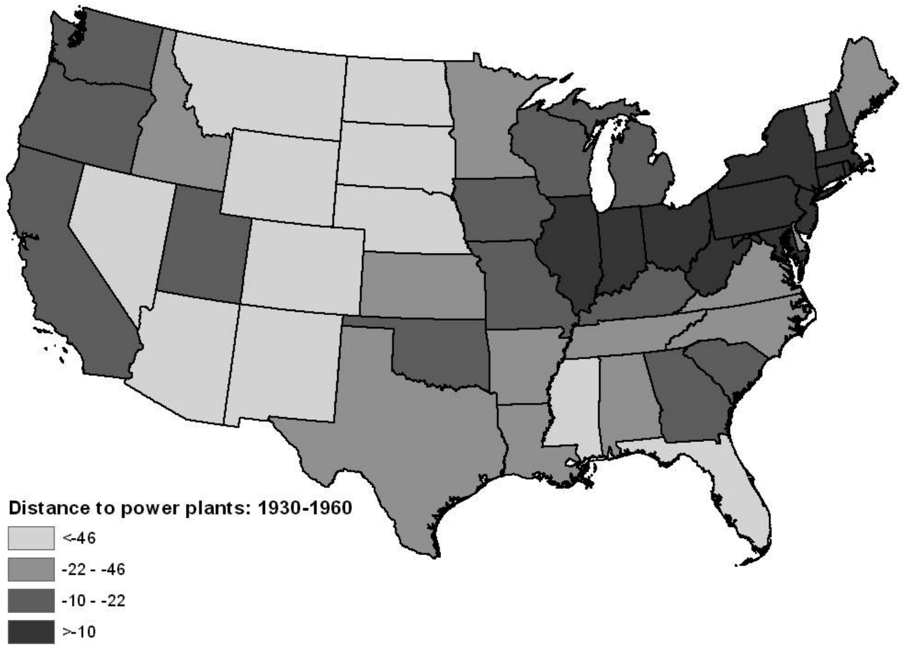


(a) Δ distance to power plants: 1940-1960

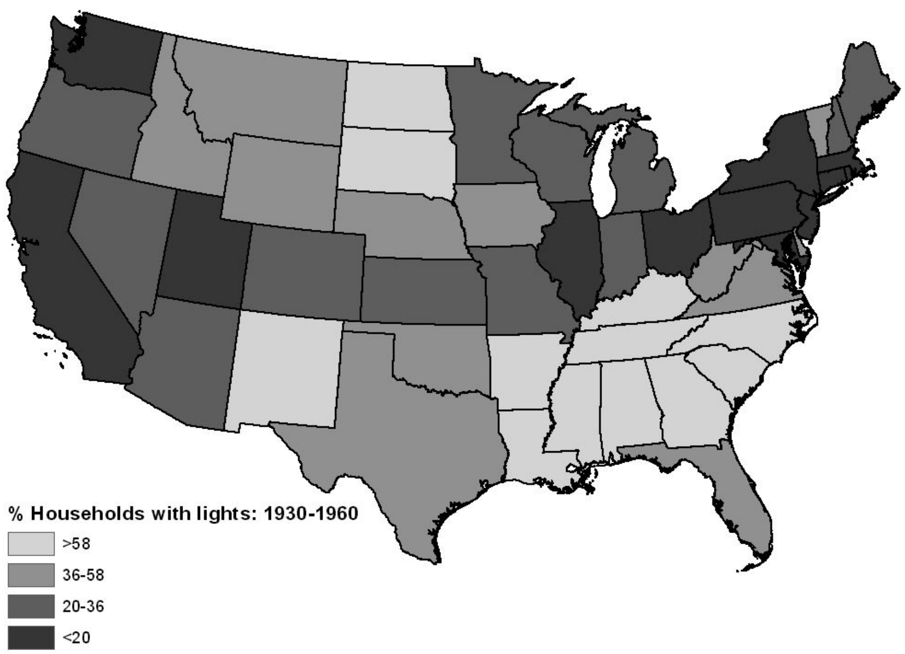


(b) Δ electric lights: 1940-1950

Figure 8: Distance to power plants and household electrification: 1930-1960



(a) Δ distance to power plants: 1930-1960



(b) Δ electric lights: 1930-1960

A Appendix

A.1 Proofs

Proof. *Proposition 1(i): The effect of household technology on human capital investment:* $\frac{\partial e'}{\partial z}$ According to Assumption 1, it is sufficient to show that $\partial e'/\partial T > 0$. I assume that $T = T'$, and totally differentiate the first order conditions (4) with respect to T. At $e' > 0$, this yields the following:

$$
\begin{aligned}
&- u''\left(w(1+\epsilon e)[T - \tau e']\right) \cdot w(1+\epsilon e)\tau \cdot \left[w(1+\epsilon e) - w(1+\epsilon e)\tau \cdot \frac{\partial e'}{\partial T}\right] \\
&+ \beta V_{e',e'}(e',T) \cdot \frac{\partial e'}{\partial T} + \beta V_{e',T}(e',T) = 0
\end{aligned}
$$

From the envelope condition, we have the following two expressions:

$$
V_{e,e}(e,T) = u''\left(w(1+\epsilon e)[T - \tau e']\right) \cdot w^2\epsilon^2 l^2 < 0, \quad \text{and}
$$

$$
\begin{aligned}
V_{e,T}(e,T) &= \left[u''\left(w(1+\epsilon e)[T - \tau e']\right) \cdot w(1+\epsilon e)[T - \tau e'] + u'\left(w(1+\epsilon e)[T - \tau e']\right)\right] \cdot w\epsilon \\
&= \left[u''(c) \cdot c + u'(c)\right] \cdot w\epsilon \geq 0
\end{aligned}
$$

The first expression is negative given the concavity in preferences over consumption. Meanwhile, Assumption 2 guarantees that the second expression is non-negative. Combining the three previous expressions and rearranging for $\partial e'/\partial T$ yields the following:

$$
\frac{\partial e'}{\partial T} = \frac{u''(c) \cdot w^2(1+\epsilon e)^2\tau - \beta\left[u''(c') \cdot c' + u'(c')\right] \cdot w'\epsilon'}{u''(c) \cdot w^2(1+\epsilon e)^2\tau^2 + \beta u''(c') \cdot w'^2\epsilon'^2 l'^2} > 0 \tag{A.1}
$$

■

Proof. *Proposition 1(ii): The effect of household technology on mother's employment:* $\frac{\partial l}{\partial z}$ Taking the derivative of the mother's time budget constraint, we have the following:

$$
\frac{\partial l}{\partial T} = 1 - \tau\frac{\partial e'}{\partial T}
$$

It is immediately apparent that

$$
\begin{aligned}
\frac{\partial l}{\partial T} > 0 \quad \text{iff} \quad \frac{1}{\tau} &> \frac{\partial e'}{\partial T} \\
\frac{1}{\tau} &> \frac{u''(c) \cdot w^2(1+\epsilon e)^2\tau - \beta\left[u''(c') \cdot c' + u'(c')\right] \cdot w'\epsilon'}{u''(c) \cdot w^2(1+\epsilon e)^2\tau^2 + \beta u''(c') \cdot w'^2\epsilon'^2 l'^2} \\
u''(c) \cdot w^2(1+\epsilon e)^2\tau^2 + \beta u''(c') \cdot w'^2\epsilon'^2 l'^2 &< u''(c) \cdot w^2(1+\epsilon e)^2\tau^2 - \beta\left[u''(c') \cdot c' + u'(c')\right] \cdot w'\epsilon'\tau \\
\frac{w'\epsilon' l'^2}{\tau} &> -\frac{u''(c')c' + u'(c')}{u''(c')}
\end{aligned}
$$

Where I substitute for $\partial e'/\partial T$ from equation (9) into the second line. Thus it follows that:

$$
\frac{\partial l}{\partial T} \gtreqless 0 \quad \text{according to} \quad \frac{w'\epsilon' l'^2}{\tau} \gtreqless -\frac{u''(c')c' + u'(c')}{u''(c')}
$$

■

Proof. *Proposition 1(iii): The effect of household technology on daughter's employment:* $\frac{\partial l'}{\partial z}$

Assuming that $T = T'$, I differentiate $l'(e'(e,T),T)$ with respect to T:

$$\frac{\partial l'}{\partial T} = \frac{\partial l'}{\partial e'} \cdot \frac{\partial e'}{\partial T} + \frac{\partial l'}{\partial T}$$

To determine the sign of this equation, I first need to establish the sign of $\partial l'/\partial e'$ or equivalently $\partial l/\partial e$. From the family time budget constraint, we have that $l = T - \tau e'$, which implies the following:

$$\frac{\partial l}{\partial e} = -\tau \cdot \frac{\partial e'}{\partial e}$$

Differentiating the FOCs with respect to e yields the following:

$$-u''(c) \cdot w(1+\epsilon e)\tau \left(w\epsilon[T - \tau e'] - w[1+\epsilon e]\tau \cdot \frac{\partial e'}{\partial e} \right) - u'(c) \cdot w\epsilon\tau + \beta V_{e',e'}(e',T) \cdot \frac{\partial e'}{\partial e} = 0$$

Rearranging and substituting for $\beta V_{e',e'}(e',T)$ yields the following:

$$\frac{\partial e'}{\partial e} = \frac{w\epsilon\tau \cdot (u''(c)c + u'(c))}{u''(c)w^2(1+\epsilon e)^2\tau^2 + \beta u''(c')w'^2\epsilon'^2 l'^2} \leq 0$$

Where the inequality follows from the concavity in preferences over consumption, and Assumption 2, which implies that $u''(c)c + u'(c) \geq 0$. Thus, we have that $\frac{\partial l}{\partial e} = -\tau \cdot \frac{\partial e'}{\partial e} \geq 0$, and similarly that $\frac{\partial l'}{\partial e'} \geq 0$. Given that $\partial e'/\partial T > 0$, it follows immediately that

$$\frac{\partial l'}{\partial T} = \frac{\partial l'}{\partial e'} \cdot \frac{\partial e'}{\partial T} + \frac{\partial l'}{\partial T} \geq \frac{\partial l}{\partial T}.$$

■

B Data sources and variable construction

The data is constructed for period 1930 to 1960 at the county-, state economic area (SEA)- and state-level. I use data for all U.S. states excluding Alaska and Hawaii. Partial county entries for Yellowstone National Park are also excluded from the analysis. The data were obtained primarily from three sources: (1) volumes of the Vital Statistics of the United States; (2) Historical, Demographic, Economic, and Social Data: The United States, 1790-2000 (Haines, 2004); (3) Integrated Public Use Micro Sample (IPUMS) (Ruggles, et al., 2010).

B.1 Education, and female employment

All county-level data on fertility and education were compiled by Michael Haines (2004), while SEA-level data come from the IPUMS (Ruggles et al., 2010).

School attendance for various ages: County-level variables for the years 1930, 1940, 1950, 1960. Calculated as the proportion of children aged 5-6 currently attending school (for the years 1940 and 1950); the proportion of children aged 7-13 currently attending school (for the years 1930, 1940, 1950, 1960); and the proportion of children aged 14-17 currently attending school (for the years 1930, 1940, 1950, 1960).

Gender-gap in school attendance: SEA-level data for the years 1930, 1940, and 1950. This variable is created as the difference in SEA-level school attendance rate by gender, based on the variable SCHOOL in the IPUMS data. I create an SEA-level mean school attendance rate separate for males and females of different age groups (age 5-6, 7-13, 14-17). The variable is constructed as the difference (males - females) for each age group.

Female employment Individual-level variable constructed for the years 1930, 1940, 1950, and 1980. This variable is constructed as an indicator for employment status from the IPUMS variable EMPSTAT.

B.2 Appliance ownership and household electricity

Data on appliance ownership and household electricity were compiled from Bailey and Collins (2011) based on data from Haines (2004) and various volumes of the *Census of Housing*.

Household electricity: County-level variable for the years 1940, 1950. Calculated as the proportion of homes with electric lights. State-level for the years 1930, 1940, 1950, 1960. The numerator is calculated as the number of residential electrical customers calculated by the Edison Electric Institute (EEI) publication, *Statistical Bulletin*. The denominator is calculated using housing unit counts from the *Census of Housing*.

Modern stoves: County-level variable for the years 1940, 1950, 1960. Calculated as the proportion of homes with modern stoves. Modern stoves are defined as stoves that used electricity, utility gas, or bottled gas as the principal cooking fuel.

Refrigerators: County-level variable for the years 1940, 1950. Calculated as the proportion of homes with a mechanical refrigerator. A mechanical refrigerator is classified as any type of refrigeration equipment powered by electricity, gas, kerosene, or gasoline; note that this equipment is distinct from an ice box.

B.3 Distance to power plants

The location of U.S. power plants was constructed using a series of seven maps conducted by the Federal Power Commission (1963). The location of each power plant was digitized using the georeferencing tools in ArcGIS. The sample is restricted to steam and hydroelectric power plants that had at least 10mw of capacity in 1960. The timing of each power plant opening is derived from directories on electric generating plants (Federal Power Commission, 1941; Federal Power Commission, 1951). This information was combined with county-centroid coordinates in 1960 to create the county-level variable for distance to the nearest power plant.

B.4 Economic and demographic covariates

Economic and demographic variables were obtained at both the county- and state-level for the years 1930, 1940, 1950, and 1960 from data compiled by Haines (2004), while SEA-level data come from the IPUMS. The key variables used are as follows:

Total population: Constructed as the total population of each county (state).

Non-white population: Calculated as the total population minus the white population.

Employment: Defined as the number of "gainful workers" in 1930, for 1940 and 1950 defined as the total employed workers, and for 1960 defined as the total employed civilian labour force.

Employment by age: This variable is constructed separately for women and men of different age groups for the years 1930, 1940, 1950, from the IPUMS dataset. The variable is constructed based on the variable EMPSTAT.

Migration: The variable is constructed for males aged 25-59 for the years 1940 and 1950 from the IPUMS dataset. The variable is equal to 1 if an individual reported having migrated from a different SEA in the past year (5 years), and is based on the variables MIGRATE5 (in 1940) and MIGRATE1 (in 1950).

Manufacturing share: In 1930, defined as the average number of wage earners divided by total employment. In 1940 and 1950, defined as workers in manufacturing divided by total employment. In 1960, defined as the labour force in manufacturing in both durable and non-durable goods divided by total employment.

Agricultural share: Total number of workers in agriculture divided by total employment .

Median home value: Median value of owner-occupied dwellings.

Farm value: Total value of farm land and buildings.

Farm size: Average number of acres per farm.

Farm value per acre: Calculate as the total value of farm land and buildings per acre of land used in farming.